EBASCO

REM III PROGRAM

REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES

EPA CONTRACT 68-01-7250

EBASCO SERVICES INCORPORATED

EPA WORK ASSIGNMENT NUMBER: 37-2LB8
EPA CONTRACT NUMBER: 68-01-7250
EBASCO SERVICES INCORPORATED

VINELAND CHEMICAL COMPANY SITE
FINAL DRAFT
FEASIBILITY STUDY REPORT
UNION LAKE
VINELAND, NEW JERSEY

JUNE 1989

NOTICE

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JUNE 1989

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LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AIC	Acceptable Chronic Intake
ARARs	Applicable or Relevant and Appropriate Requirements
ASC	Acceptable Soil Concentration
ASTM	American Society of Testing and Materials
AWQC	Ambient Water Quality Criteria
BEHP	bis(2-ethylhexyl)phthalate
BNA	Base-Neutral/Acid Extractables
°C	Degrees Centigrade
CDI	Chronic Daily Intake
CDL	Contract Detection Limit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLP	Contract Laboratory Program
CRAVE	Carcinogen Risk Assessment Verification Endeavor
DMAA	Dimethyl Arsenic Acid
DQO	Data Quality Objectives
ECRA	New Jersey Environmental Cleanup Responsibility Act
EDTA	Ethylenediaminetetra-acetate
EM	Electro Magnetic Conductivity Survey
EP	Extraction Procedure
EPIC	Environmental Photographic Information Center
ER	Ebasco River Sampling Station
EW	Ebasco Well
FS	Feasibility Study
GPD	Gallons Per Day
GPM	Gallons Per Minute
HEA	Health Effects Assessment
HSL	Hazardous Substances List
IDL	Instrument Detection Limit
IRIS	Integrated Risk Information System
Kd	Partitioning Coefficient
LL	Lined Lagoon
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MEP	Multiple Extraction Procedure
MG/KG	Milligrams Per Kilogram
MG/L	Milligrams Per Liter
MMAA	Monomethyl Arsenic Acid
MSL	Mean Sea Level
MW	Monitoring Well
NCDC	National Climatic Data Center
NCP	National Contingency Plan
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollution Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
ODW	Office of Drinking Water
OHEA	Office of Health and Environmental Affairs
OSHA	Occupational Safety and Health Administration

PCB	Polychlorinated biphenyls
PMSA	Primary Metropolitan Statistical Area
PPB	Parts Per Billion
PPM	Parts Per Million
PSI	Pounds Per Square Inch
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMCL	Recommended Maximum Contaminant Level
RfD	Reference Dose
SAS	Special Analytical Services
SNARL	Suggested-No-Adverse Response Level
SPDES	State Pollution Discharge Elimination System
SU	Standard Units
TCE	Trichloroethylene
TCL	Target Compound List
TOC	Top of Casing
TOC	Total Organic Carbon
UCS	Unconfined Compressive Strength
UG/L	Micrograms Per Liter
UL	Unlined Lagoon
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	Ultraviolet
VES	Vertical Electrical Soundings
ViChem	Vineland Chemical Company

EXECUTIVE SUMMARY

The Union Lake Feasibility Study (FS) is one of three FS reports being prepared for the Vineland Chemical Company (ViChem) work assignment. The FSs include:

- The ViChem plant site proper;
- The River Areas, consisting of the Blackwater Branch (the receiving stream from the ViChem plant) and the Maurice River from its confluence with the Blackwater Branch to Union Lake; and
- Union Lake, an 870-acre impoundment on the Maurice River.

Three Remedial Investigation (RI) reports are being prepared and submitted to the USEPA for the ViChem work assignment as follows:

- The ViChem plant site proper;
- The River Areas, consisting of the Blackwater Branch, the Maurice River from its confluence with the Blackwater Branch to Union Lake, and the Maurice River below Union Lake to the Delaware Bay; and
- Union Lake.

The purpose of the Union Lake FS was to develop, screen, and evaluate potential remedial alternatives to address sediment contamination found to cause increased health risks or environmental impacts. This report was prepared in accordance with the USEPA's March 1988 Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.

The ViChem site is ranked among the top ten hazardous waste sites in New Jersey and is ranked number 42 on the National Priorities List. ViChem has manufactured organic arsenical herbicides and fungicides at this plant since 1949. The 54-acre facility is located in the northwest corner of the city of Vineland in Cumberland County, New Jersey. The plant is situated in a partly residential and partly industrial area.

The Blackwater Branch flows past the ViChem plant and receives groundwater discharge from it. From the plant, the Blackwater Branch flows approximately 1.5 miles before its confluence with the Maurice River. The Maurice River flows into Union Lake approximately 8.5 miles downstream from this confluence. The Maurice River flows into the Delaware Bay approximately 25 miles downstream from Union Lake.

Detailed information on the past use, storage, and disposal of all process materials at the plant is not available. It is known, however, that waste salts (listed hazardous waste K 031) containing arsenic were piled outdoors, and that precipitation contacting the piles flushed arsenic into the groundwater. Also, the plant previously discharged untreated process water into lagoons, and the water was allowed to percolate into the groundwater. The contaminated groundwater subsequently discharged into the Blackwater Branch and was distributed downstream in the Maurice River drainage system.

Previous investigations have shown elevated arsenic concentrations in surface waters and sediments as far as 26.5 river miles downstream from the plant in the Maurice River. It was suspected that a serious groundwater contamination problem existed at the plant.

In the Union Lake RI it was determined that arsenic was the main contaminant of concern. Pertinent findings from the RI are as follows:

- Arsenic was found to be the main contaminant of concern. The sediment and water in Union Lake both had elevated arsenic concentrations. The mean arsenic concentration in the sediment was 74 mg/kg. Upstream of the ViChem plant site, arsenic was undetected in the sediments. The mean total arsenic concentration in the lake water was 56 ug/l. This is slightly above the Federal Primary Drinking Water Standard for arsenic of 50 ug/l. Arsenic was undetected in the surface water upstream from the ViChem plant.

- Arsenic was detected in some fish samples at low concentrations (1 mg/kg). Low concentrations (less than 1 mg/kg) of PCBs were also detected in some fish samples. PCBs were not analyzed in the water and sediments of the lake. They were analyzed upstream from the lake, but were found only sporadically at low concentrations.

- The arsenic distribution in the sediments was very heterogeneous. Samples taken in close proximity to one another varied greatly in arsenic concentration. While the data base within the lake was limited, in other areas in the basin arsenic correlated positively with increased organic content and increased fine size fraction content.

- Background studies performed by other investigators showed that arsenic bound very strongly to the organics in sediments. A maximum of 50% was leachable even under strongly acidic conditions. The estimated partition coefficient between arsenic on the organic sediments and water was a maximum of 1,100.

Since Union Lake is part of a dynamic system, the fate and transport of arsenic within the watershed as a whole was pertinent to this FS. Findings from the other RI reports that relate to this FS are as follows:

- In the Plant Site RI, it was shown that groundwater discharge off the plant site was the main source of arsenic into the watershed. An estimated 6 metric tons of arsenic per year were being discharged into the Blackwater Branch from the plant site in 1987. The previous rate of release was probably much higher. The groundwater discharge flows into the Blackwater Branch; it does not flow beneath it.

- The Blackwater Branch and the upper Maurice River above Union Lake basically behave as conduits for arsenic transport. That is, they presently transport arsenic released from the site into Union Lake. Because of this, it was estimated that if the source of arsenic were eliminated (e.g., if a groundwater remediation program were initiated at the ViChem site to prohibit contaminated groundwater from entering the Blackwater Branch), then the river water arsenic concentration should drop relatively quickly.

- Union Lake has been a large receptor of the arsenic released from the site. Of the estimated 500 metric tons of arsenic released over time, an estimated 150 metric tons are now bound to Union Lake's sediments.

- It could not be determined what controlled the arsenic concentration in Union Lake's water. On one hand, the arsenic concentrations coming in, within, and going out of the lake were approximately the same. On the other hand, the lake's water and sediment were apparently at equilibrium, based on the mean arsenic concentration in the water and sediments and the partition coefficient. Therefore, the controlling mechanism for the lake's water arsenic content, the incoming water or desorption from the sediments, could not be determined. The significance of this was that if the source of arsenic into the basin were eliminated, it could not be definitively stated that the lake's arsenic concentration would also be reduced. Almost certainly it would be reduced, but how much and how quickly could not be determined.

The risk assessment presented in the RI considered a number of exposure pathways to the lake's water, sediment, and fish. Exposure scenarios were calculated considering recreational usage of the lake, since it is a popular recreational area. Risks were calculated on a "most plausible" and a "worst case" basis to provide a range of estimates. Risks were calculated for a range of conditions; lake full, lake drawn down for dam spillway reconstruction, and lake drawn down because of drought. Pertinent findings of the risk assessment were as follows:

- Very little increased risk resulted from lake drawdown. Risks during the period of drawdown considered were in the range of 1×10^{-8}, or one predicted incident of cancer per one hundred million persons exposed.

- Slightly increased risks were calculated for accidental water ingestion. The most plausible risks were approximately 6×10^{-6} (six incidents of cancer per one million persons exposed), while the worst case risks were approximately 4×10^{-5} (four incidents of cancer per one hundred thousand persons exposed).

- Increased risks from fish ingestion were calculated. The majority of the risks were from the low levels of PCBs found in the fish (within USDA dietary standards). The PCBs are not believed to be related to the ViChem site. The calculated arsenic risks from fish ingestion were probably overestimated since the form of arsenic in fish is believed to be relatively nontoxic.

- Accidental sediment ingestion during recreation risks were 6×10^{-6} (six incidents of cancer per one million persons exposed) by the most plausible pathway, and 7×10^{-4} (seven incidents of cancer per ten thousand persons exposed) by the worst case pathway. This pathway was considered valid only for sediments in very shallow water, less than two and one half feet deep.

- To account for arsenic heterogeneity in the lake sediments and possible hot spots, acceptable sediment arsenic concentrations were back calculated from the most plausible exposure pathways. A sediment arsenic concentration of 120 mg/kg back calculated to a risk of 1×10^{-5} (one incident of cancer per one hundred thousand persons exposed). These sediments would be under very shallow water, less than two and one half feet deep.

A remedial action objective was established to address the contamination in the lake. Since the source of lake water contamination (the incoming water or desorption from the lake sediment) could not be determined, and because of the impracticality of treating the approximate 2.7 billion gallons of water in the lake discharging at a median rate of 325 cfs, remedial alternatives for the lake water were not considered. Also, since there was some question regarding the actual fish ingestion risks, remedial objectives for this problem were also not considered. Therefore, a remedial action objective was established for the contaminated sediments as follows:

- Minimize public access, either through containment, removal, or institutional controls, to areas with unacceptably high sediment arsenic concentrations.

The FS established the following remedial strategy to achieve the remedial action objective:

- In the most accessible areas of the lake (the public beach and the tennis and sailing club) all sediments underlying a water depth of less than five feet with an arsenic concentration of 20 mg/kg or greater would be remediated.

- In the residential areas of the lake along the eastern shoreline, all sediments underlying a water depth of less than two and one-half feet with an arsenic concentration of 20 mg/kg or greater would be remediated. Thereafter, the remediation would be extended to remove sediments with an arsenic concentration above 20 mg/kg within 150 feet of the shoreline, up to a five foot water depth.

- For the remaining areas of the lake, where activities that promote sediment ingestion are less likely to be engaged in, the action level would be 120 mg/kg. Remediation would be conducted to a two and one-half foot water depth at a minimum. Thereafter, the remediation would be extended to remove sediments with an arsenic concentration above 120 mg/kg within 150 feet of the shoreline, up to a five foot water depth.

The target cleanup level corresponds to a cancer risk of 2×10^{-6} in the more accessible areas of the lake, and 1×10^{-5} in the less accessible areas of the lake using the most plausible exposure pathway models.

The lake is now drawn down to facilitate dam reconstruction. It is expected that construction will be complete and that the lake will be refilled by June of 1990. Because of the likely timing of remedial actions at the site, with upstream actions being taken prior to downstream actions, it is unlikely that any remedial action in the lake could be taken until after the lake has been refilled. However, NJDEP owns and operates the lake and could either postpone refilling the lake until the remediation is complete or refill the lake after the dam reconstruction and draw it back down at the initiation of the remedial action. The remedial alternatives are therefore examined considering the lake to be at its full condition and at drawdown.

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Several interpretations of the site conditions by USEPA Headquarters Site Policy and Guidance Branch personnel affected this FS:

1) Lake sediments contaminated with arsenic are themselves the listed hazardous waste K 031. This is based on the belief that the lake sediments were contaminated with arsenic from the listed hazardous waste K 031 produced on the ViChem site. If excavated, these sediments have to be treated and delisted prior to disposal as non-hazardous materials.

2) If disposal is off-site, delisting would involve a petition to the NJDEP. A substantive portion of this petition requires the treated sediments to have an arsenic concentration of less than 0.32 mg/l in the extract from an EP Toxicity Test. This concentration is stipulated by the VHS model, which is a substantive delisting tool.

3) If the treated sediments are disposed of on-site, a delisting petition to the NJDEP would not be required. The USEPA's Region II Regional Administrator could decide that nonhazardous disposal is appropriate on the basis of the treated sediments meeting the substantive delisting requirement, which in this case is the 0.32 mg/l arsenic level in an EP Toxicity extract from the treated sediments.

4) If the treated sediments cannot pass the EP Toxicity Test criterion of 0.32 mg/l arsenic, but have an EP Toxicity Test concentration of 1 mg/l arsenic or less, they cannot be disposed of as nonhazardous material, but could be disposed of as hazardous material in a RCRA Subtitle C landfill. The 1 mg/l criteria was termed a "treatability variance" for the sediment.

5) If the treated sediments do not pass the EP Toxicity Test criterion of 1 mg/l arsenic, they cannot be disposed of at all in any type of landfill facility (the "land ban"). A different treatment technology or remedial technology would have to be selected.

6) The lake areas are considered part of the site, since they are within the "area of contamination" from the site. The areas adjacent to the lake are not considered part of the site. This means that an "on-site" landfill cannot be constructed adjacent to the lake, but must be located on the ViChem plant property.

Two bench-scale treatability tests were performed to meet the sediment cleanup objective: chemical fixation and chemical extraction. Based on the treatability studies, other information gathered in the RI, and other information from vendors, it is expected that the fixation could chemically stabilize or physically bind the arsenic to the sediments such that leachable arsenic concentrations would be less than 0.32 mg/l (as established by the VHS model, the substantive delisting tool). It is also expected that the fixated product would have an unconfined compressive strength of 1,500 pounds per square foot (PSF). By meeting these criteria, the fixated product would be expected to be delistable and could be disposed of in a nonhazardous waste landfill. The extraction test determined that arsenic could be removed from the sediments such that the extracted sediments had an arsenic concentration of 34 mg/kg. Based on results of EP Toxicity Tests conducted on untreated sediments and other information gathered in the RI, it was expected that the extracted sediment would have leachable arsenic concentrations less than 0.32 mg/l. Thus it could be disposed of in a nonhazardous landfill. The extractant could be treated to meet MCLs and could be discharged back to the lake. The sludge generated from the extraction process would be transported off-site to a RCRA treatment and disposal facility. Since both treatment technologies were successful in the tests, both were considered in the FS.

A number of general response actions and technologies were considered to achieve the remedial action objective. The general response actions include no action, containment, treatment, and removal.

Technologies to meet the general response actions were identified. Technologies for the no action response include monitoring, restricted use, and public awareness. Containment technologies include capping the sediments with sand, clay, and manmade liners. Removal and treatment technologies include removing the sediments, extracting or fixation of the removed sediments, and in situ treatment methods.

These technologies were screened to eliminate technologies that are (1) unproven, (2) would not meet the remedial action objective, and (3) would be difficult to implement due to the nature of the site and/or the nature of the contaminants.

The technologies that passed this screening were then combined to form overall remedial action alternatives in accordance with the NCP Section 300.68(f). The remedial alternatives considered for addressing the contamination were:

<u>SOURCE CONTROL</u>

- o Alternative 1: No Action
- o Alternative 2A: Removal/Fixation/Off-Site Nonhazardous Landfill

- Alternative 2B: Removal/Fixation/On-Site Nonhazardous Landfill
- Alternative 2C: Removal/Fixation/Lake Deposition
- Alternative 3A: Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
- Alternative 3B: Removal/Extraction/Sediment to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
- Alternative 3C: Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal
- Alternative 3D: Removal/Extraction/Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal
- Alternative 4A: Removal/Off-Site RCRA Disposal
- Alternative 4B: Removal/On-Site RCRA Disposal
- Alternative 5: In Situ Sand Cover

Removal of the sediments was common to all of the alternatives except Alternative 1, No Action, and Alternative 5, In Situ Sand Cover. If remediation is conducted when the lake is at its full condition, hydraulic dredging would be implemented to remove the submerged contaminated sediments. If remediation is conducted when the lake is at drawdown, the exposed contaminated sediments would be removed utilizing dry excavation techniques.

Alternatives 2A, 2B, 2C, 3A, 3B, 3C, and 3D differed from one another in the type of sediment treatment (fixation or extraction) and in the disposal options for the treated sediments (off-site in an existing nonhazardous landfill, on-site in a newly constructed nonhazardous landfill built for the treated sediments only, lake deposition of the treated sediments or plant site deposition of the treated sediments). Alternatives 4A and 4B differed from the others in that the removed sediments would not be treated and would be disposed of in an existing off-site or in a newly constructed on-site RCRA Subtitle C landfill facility. Alternative 5 differed from the others in that the sediments would not be removed or treated. The in situ sand layer would provide containment of the contaminated sediments.

An initial screening of these alternatives was performed based on three criteria: effectiveness, implementability, and cost.

The alternatives were screened against these criteria, and were compared one against another to find the most promising alternatives to take into detailed evaluation.

Factors considered to determine an alternative's effectiveness were its ability to protect the public health and the environment, and its ability to reduce the mobility, toxicity, or the volume of the contamination. Factors considered to determine an alternative's implementability included its overall feasibility of implementation, its established or estimated reliability, and the availability of necessary equipment and services. Cost screening at this initial stage was performed on an order-of-magnitude basis, with only those alternatives that exceeded another's cost by an order of magnitude being eliminated on the basis of cost.

Alternative 1, No Action, was retained for evaluation because it serves as the base case against which the other alternatives were compared. Alternatives 2A, 2B, 3A, 3B, 3C, and 3D all met the remedial action objective, were considered implementable, and did not vary by an order of magnitude in costs. These were all retained for further detailed evaluation. Alternative 2C was not considered implementable. Fixation would immobilize the arsenic; no reduction in toxicity of the arsenic would be realized. If the fixated material leached appreciable amounts of arsenic to the lake, there is no feasible method to monitor or recover the deposited material. Therefore Alternative 2C was eliminated from further evaluation. Alternatives 4A and 4B were eliminated from further evaluation because they would not meet the forthcoming land disposal restrictions and would not provide for a permanent remedy.

The alternatives that passed the initial screening were then further evaluated in detail with respect to the nine criteria stipulated in CERCLA as amended, OSWER Directive No. 93SS.0-19 and the statutory factors described in OSWER Directive No. 93SS-21. The nine criteria are: short-term effectiveness; long-term effectiveness; reduction of toxicity, mobility or volume of contamination; implementability; cost; compliance with ARARs; overall protection of human health and the environment; state acceptance; and community acceptance. A summary of the detailed evaluation of the alternatives that passed the initial screening is discussed below.

SOURCE CONTROL

Alternative 1, No Action, provides the baseline against which the other responses can be compared. There would be no substantial remediation activities involved; therefore there would be no reduction in potential environmental contamination. Public access to the lake would be reduced by sign posting and educational programs. This would not meet the statutory requirements of reducing the toxicity, mobility, or volume of contaminants. This alternative is easy to implement, but would not attain ARARs.

All of the alternatives except Alternative 1, No Action, and Alternative 5, In Situ Sand Covering, consider remediation to be conducted when the lake is at its full condition, requiring the implementation of hydraulic dredging, and when the lake is at drawdown, requiring the use of dry excavation. Removal of the submerged sediment by dredging would not generate fugitive dust emissions, which is potentially associated with dry excavation of the exposed sediments, thus having minimal impacts to the surrounding communities. However, dredging would potentially cause resuspension of the contaminated sediments, resulting in the formation of a contaminant plume. Dry excavation would have fewer associated adverse environmental impacts, including minimal disturbance to any wetland area. Additionally, excavation would enable more control in the areal and vertical extent of sediment removal.

Alternative 2A would entail removing the contaminated sediments in the lake and treating them via fixation. The fixed product would be disposed in a nonhazardous off-site landfill. This alternative would achieve the cancer target risk level in the sediments identified as a public health risk. It would slightly reduce the toxicity, mobility, and volume of contaminants in the lake. It would reduce the mobility and volume of contaminants overall, but not their toxicity. Fixation binds the arsenic, it does not change its form. Long-term monitoring would be required to monitor the sediment redistribution patterns in the lake. If significant redistribution occurs causing a public health risk, additional remedial actions may be required. Possible environmental impacts include disturbing the lake and adjacent areas during construction, and impacts from truck traffic.

Alternative 2B is the same as Alternative 2A except that the fixed sediments would be disposed of in a nonhazardous landfill built specifically for this purpose. The landfill would be constructed at the ViChem plant site. The same reductions in toxicity, mobility, and volume would be realized as with Alternative 2A, and the reduction of risk in the lake sediments would be achieved with the same potential dredging impacts. This alternative would also require long-term maintenance to ensure that the landfill does not leach contaminants, as well as long-term monitoring of the remaining contaminated sediments.

Alternative 3A entails the same sediment removal activity as 2A and 2B. Instead of being fixated, however, the arsenic would be extracted from the sediments. The extracted sediments would be disposed of in an off-site nonhazardous landfill. The extractant would be treated with a fairly complicated system to remove arsenic prior to its discharge into the lake. The sludge containing the extracted arsenic would be transported off-site to a RCRA treatment and disposal facility by a licensed vendor. This alternative also reduces the toxicity, mobility, and volume of contaminants in the lake that were identified as a public health risk. Alternative 3A also reduces the toxicity and mobility of the contaminants overall, but not their volume. Long-term monitoring would be required to measure the effectiveness of this alternative. If sediment redistribution results in a public health risk, additional remedial actions may be required.

Alternative 3B is the same as 3A except that the extracted sediments are disposed of in an on-site nonhazardous landfill. The landfill would be located at the ViChem plant site. Administration approvals and land acquisition would be required. This alternative achieves the same reduction in toxicity, mobility, and volume of contaminants as 3A. Additional long-term maintenance and monitoring would be required to insure the landfill's integrity.

Alternatives 3C and 3D are similar to Alternative 3A, except that the treated sediments are deposited in the previously excavated/dredged areas of the lake or on the ViChem plant site, respectively. These disposal options require delisting of the treated sediments and classification as non-ID 27 waste. Thus, the impacts to human health and the environment would be demonstrated as minimal prior to implementation of the alternative. These alternatives would achieve the same reduction in toxicity, mobility, and volume of contaminants as Alternative 3A. Long-term monitoring would be required. Alternative 3C would be more cost-effective than Alternative 3D, as the need for backfill material in the dredged/excavated areas of the lake would be eliminated.

Alternative 5 would not require any removal of contaminated sediments. Instead, they would be capped with a one foot layer of sand. This alternative would not reduce the volume or toxicity of the contaminated sediments, but would reduce their mobility. This alternative would require long-term monitoring to ensure that the sand layer was not eroded. If this occurred, a reapplication of sand may be required. Also, it is possible that the clean sands used as cover could become contaminated through contact with the sediments.

Tables E-1 and E-2 present the present worth costs assuming a 5% discount rate for the alternatives with the lake at its full condition and the lake at drawdown. Because the O&M costs for all of the alternatives are either low or nonexistent, the costs are not sensitive to different discount rates.

TABLE E-1

SUMMARY OF COST ANALYSIS (1989 DOLLARS)
(DREDGING CASE)

ALT	CAPITAL COST			ANNUAL O&M		PRESENT WORTH
	DIRECT	INDIRECT	TOTAL	LONG TERM	SHORT TERM	
1	$35,000	$9,450	$44,450	$49,455		$874,245
2A	$27,237,097	$7,354,016	$34,591,114	$13,020	$20,562,475	$71,246,971
2B	$10,820,246	$2,921,466	$13,741,713	$89,530	$20,562,475	$51,413,566
3A	$20,268,107	$5,472,389	$25,740,496	$13,020	$1,832,012	$29,227,193
3B	$12,611,824	$3,405,192	$16,017,016	$60,398	$1,832,012	$20,132,854
3C	$8,870,451	$2,395,022	$11,265,473	$13,020	$1,832,012	$14,752,170
3D	$11,610,914	$3,134,947	$14,745,861	$13,020	$1,832,012	$18,232,558
5	$2,476,276	$668,594	$3,144,870	$13,020		$3,368,883

TABLE E-2

SUMMARY OF COST ANALYSIS (1989 DOLLARS)
(EXCAVATION CASE)

ALT	CAPITAL COST			ANNUAL O&M		PRESENT WORTH
	DIRECT	INDIRECT	TOTAL	LONG TERM	SHORT TERM	
2A	$25,446,160	$6,870,463	$32,316,623	$13,020	$20,487,428	$68,839,581
2B	$9,029,350	$2,437,925	$11,467,275	$89,530	$20,487,428	$49,006,227
3A	$18,876,051	$5,096,534	$23,972,585	$13,020	$1,808,043	$27,416,835
3B	$11,219,788	$3,029,343	$14,249,130	$60,397	$1,808,043	$18,322,520
3C	$7,478,424	$2,019,174	$9,497,598	$13,020	$1,808,043	$12,941,849
3D	$10,218,882	$2,759,098	$12,977,980	$13,020	$1,808,043	$16,422,231
5	$1,713,651	$462,686	$2,176,336	$13,020		$2,400,349

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) on May 9, 1986 authorized Ebasco Services Incorporated (Ebasco) to conduct a Remedial Investigation/Feasibility Study (RI/FS) on the Vineland Chemical Company (ViChem) plant site in Vineland, New Jersey. The RI/FS was performed in response to Work Assignment Number 37-2LB8 under Contract Number 68-01-7250. Preparation of this report was accomplished pursuant to the approved Work Plan for the ViChem plant site dated November 17, 1986, as amended in October, 1987.

Three RI and three FS reports have been prepared for the ViChem plant site. The reports, the areas they cover, and the dates of submission to USEPA are presented in Table 1-1.

The study area is approximately 38 miles long: 11 miles of riverine environment (including two miles upstream of the plant); 2 miles of lacustrine environment; and 25 miles of estuarine environment. This report addresses the Union Lake site itself. The location of the study area is shown in Figures 1-1 and 1-2. A description of the site is presented in Section 1.2.

1.1 PURPOSE AND ORGANIZATION OF THE REPORT

The objective of the Union Lake FS was to develop and screen feasible remedial alternatives to remediate environmental contamination found in Union Lake. The most promising alternatives were evaluated against a range of factors and compared against one another. This evaluation would provide a basis for the USEPA to select the best remedial alternative for the site. Specifically, the FS objectives were threefold:

- Identify feasible remedial technologies for containment, removal or treatment of arsenic-contaminated sediments;
- Screen and assemble the feasible technologies into remedial alternatives for detailed analysis; and
- Evaluate and compare the remedial alternatives to provide the basis for the USEPA's selection of the best remedial alternative.

Subpart F of the NCP (40 CFR 300.61-300.71) sets forth the FS process by which remedial alternatives were assembled, evaluated and selected. The factors that were considered in the process are cited under the requirements of Section 105.

This FS was prepared utilizing the data and information presented in the Union Lake RI (Ebasco, 1989e). Information from the River Areas RI (Ebasco, 1989c) and the Plant Site RI (Ebasco, 1989a)

VIN 002 0230

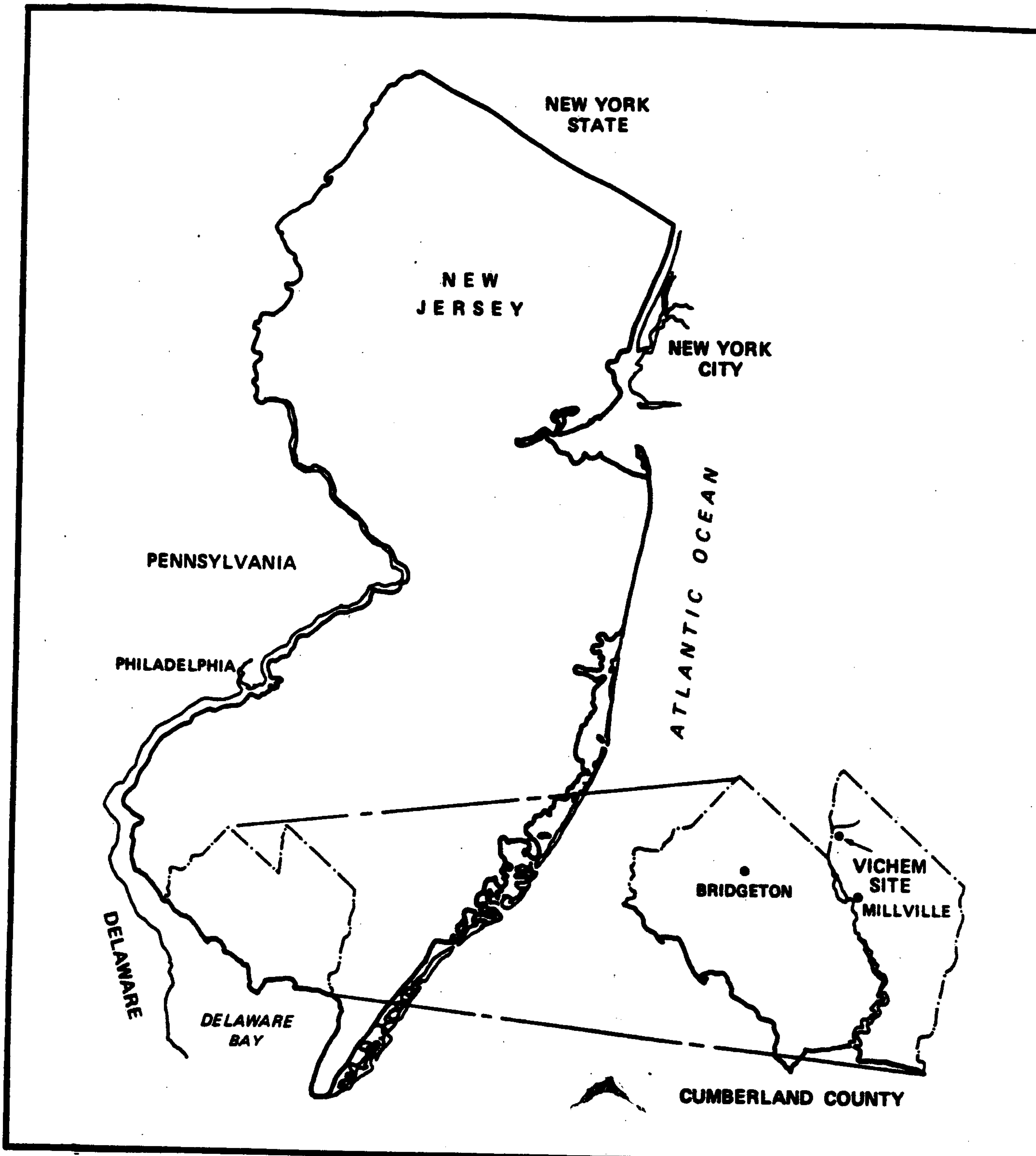
TABLE 1-1

RI AND FS REPORTS PREPARED FOR THE VINELAND CHEMICAL COMPANY SITE

TITLE	AREAS	MEDIA INVESTIGATED	DRAFT	REVISED DRAFT	FINAL DRAFT
Plant Site RI	ViChem Plant Site	Soil, Groundwater	7/19/88	3/10/89	6/23/89
River Areas RI	Blackwater Branch, Maurice River between Blackwater Branch and Union Lake, Maurice River below Union Lake to Delaware Bay	Sediment, Surface Water, Biota	9/8/88	2/17/89	6/23/89
Union Lake RI[1]	Union Lake	Sediment, Surface Water, Biota	6/21/88	4/28/89	6/23/89
Plant Site FS	ViChem Plant Site	Soil, Groundwater	9/20/88	3/10/89	6/23/89
River Areas FS[2]	Blackwater Branch, Maurice River between Blackwater Branch and Union Lake	Sediment	10/5/88	4/27/89	6/23/89
Union Lake FS	Union Lake	Sediment	1/18/89	4/14/89	6/23/89

1 Risk assessment submitted on April 20, 1987. First Draft RI submitted on March 13, 1988. The June 21, 1988 RI incorporated the first revised risk assessment.

2 No FS Report is being prepared for the Maurice River below Union Lake. Sampling in this area was confirmational only.



U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1—1

VINELAND CHEMICAL COMPANY REGIONAL LOCATION MAP

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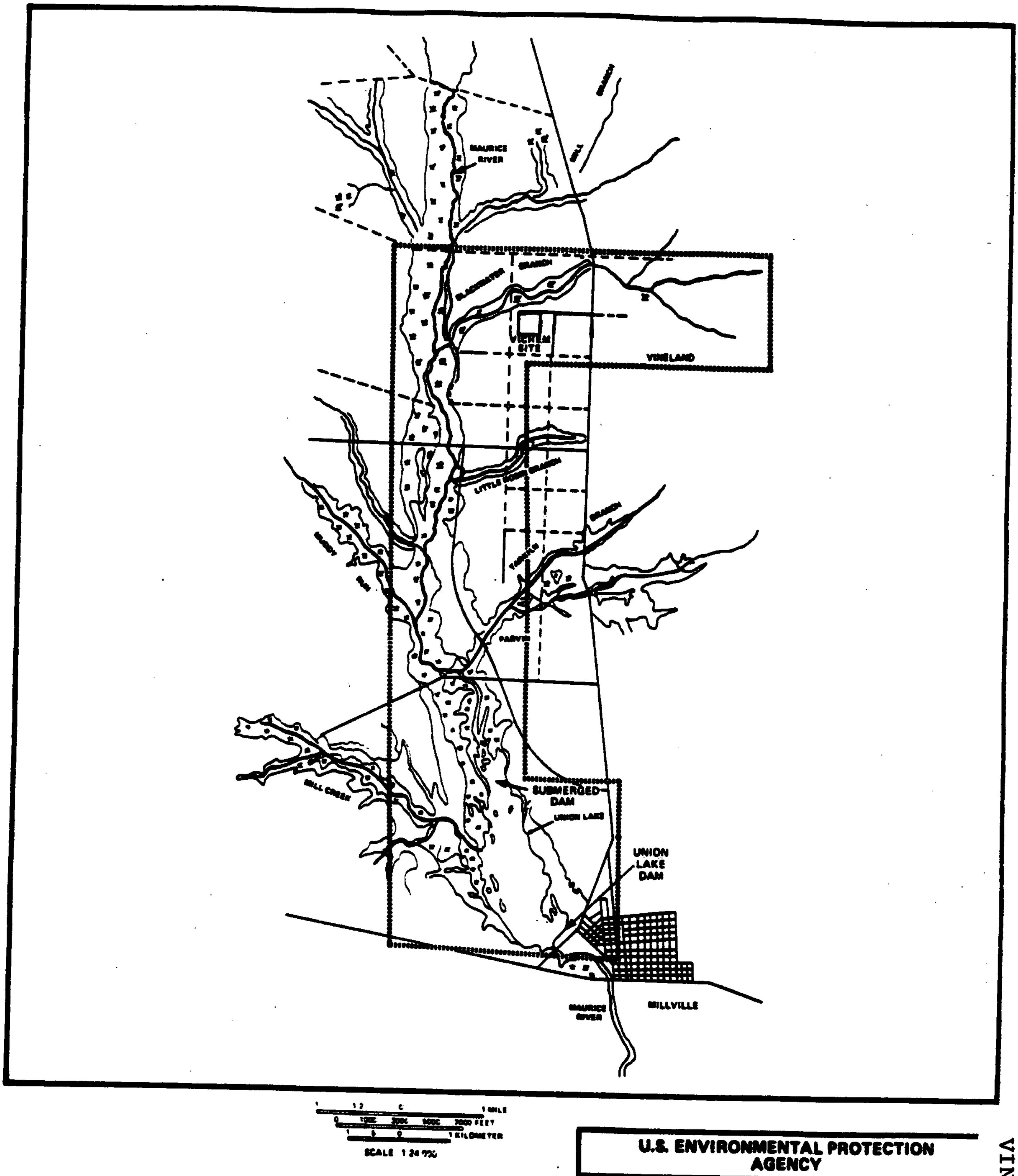

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1-2

VINELAND CHEMICAL COMPANY SITE STUDY AREA

SHEET 1 OF :

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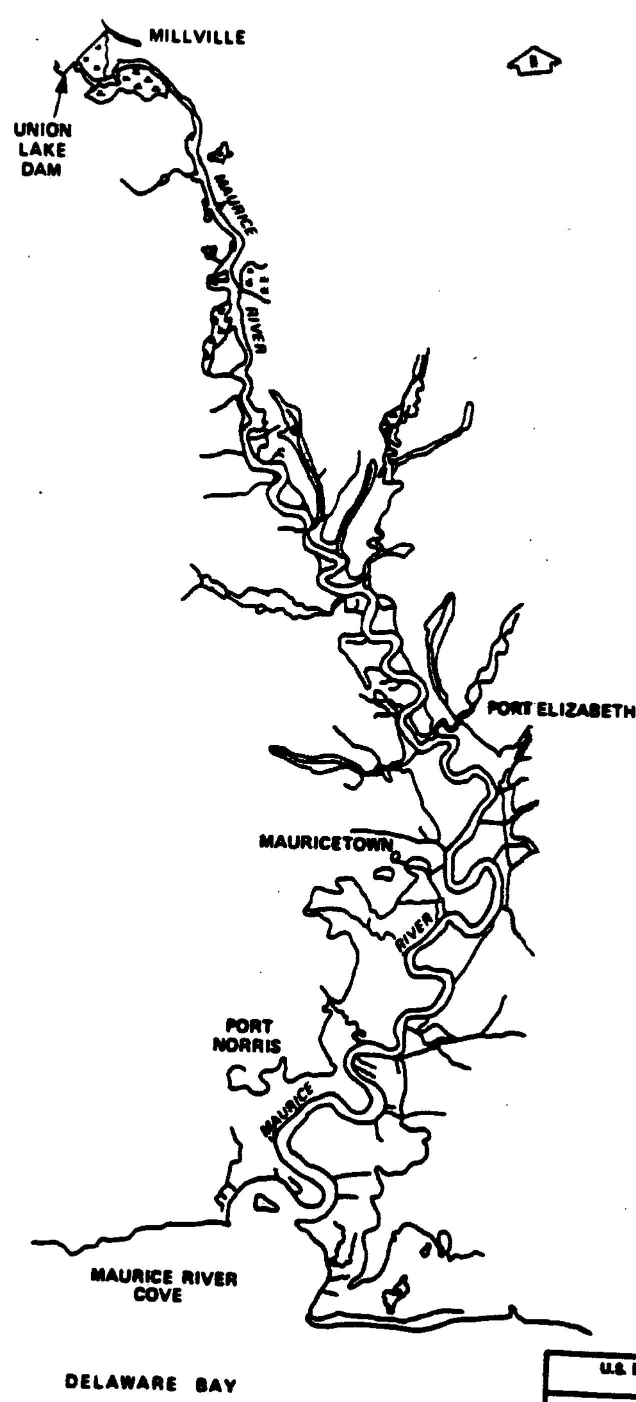


U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1-2

VINELAND CHEMICAL COMPANY STUDY AREA

SHEET 2 OF 2

EBASCO SERVICES INCORPORATED

VIN 002 0234

was also considered, as these reports detail the environmental contamination observed upstream of Union Lake. Ultimately, remedial measures at the Union Lake site must consider not only the contamination at the lake itself, but also the migration of contamination stemming from upstream sources.

This report is comprised of four sections and three appendices. The report was prepared following the USEPA's Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988a).

The Introduction, Section 1.0, provides background information regarding the site location, geology and hydrogeology, site contamination, history and regulatory actions. The nature and extent of the contamination, as identified in the RI, are also summarized in this section.

Section 2.0 presents the feasible technologies with which to meet the general response actions, the technical criteria and the site-specific requirements that were used in the technology selection process, and the results of the remedial technology screening. A summary of the objectives for remedial action(s) is also presented, along with a summary of applicable environmental criteria and standards.

Section 3.0 presents the remedial alternatives developed by combining the technologies that passed the screening in Section 2.0. Alternatives were developed in the three general categories required by the Superfund Amendments Reauthorization Act (SARA): No Action, containment and treatment. The process for screening the remedial alternatives is also described. A description of the environmental and public health impacts and the estimated costs for each alternative are presented. The most promising alternatives to be taken into detailed evaluation in each of the three categories are identified.

Section 4.0 presents the detailed evaluations of the most promising alternatives developed in Section 3.0. This section presents the detailed descriptions of the cost and non-cost features of each remedial alternative that passed the screening in Section 3.0. The analysis of each alternative against nine assessment criteria is presented. Finally, this section summarizes the remedial alternatives and compares them to one another.

All of the references and previous studies cited in this report, as well as the other documents used to conduct the FS, are listed in the References Section at the end of this report.

The report contains three appendices:

- o Appendix A, Major Facilities and Construction Components, presents the construction components and associated quantities for the remedial alternatives in Section 4.0;

- Appendix B, Capital and Operation and Maintenance (O&M) Cost Estimates for Remedial Activities that Involve Dredging, presents material and installation costs yielding direct and total construction costs for the dredging cases of the remedial alternatives presented in Section 4.0 and presents the O&M costs for the alternatives as required;

- Appendix C, Capital and Operation and Maintenance (O&M) Cost Estimates for Remedial Activities that Involve Excavation, presents material and installation costs yielding direct and total construction costs for the excavation cases of the remedial alternatives presented in Section 4.0 and presents the O&M costs for the alternatives as required; and

- Appendix D, Statistical Analyses of Sediment Arsenic Data, presents a discussion of the statistical methods used to estimate the quantity of contaminated sediment to be treated at the Union Lake site.

1.2 BACKGROUND INFORMATION

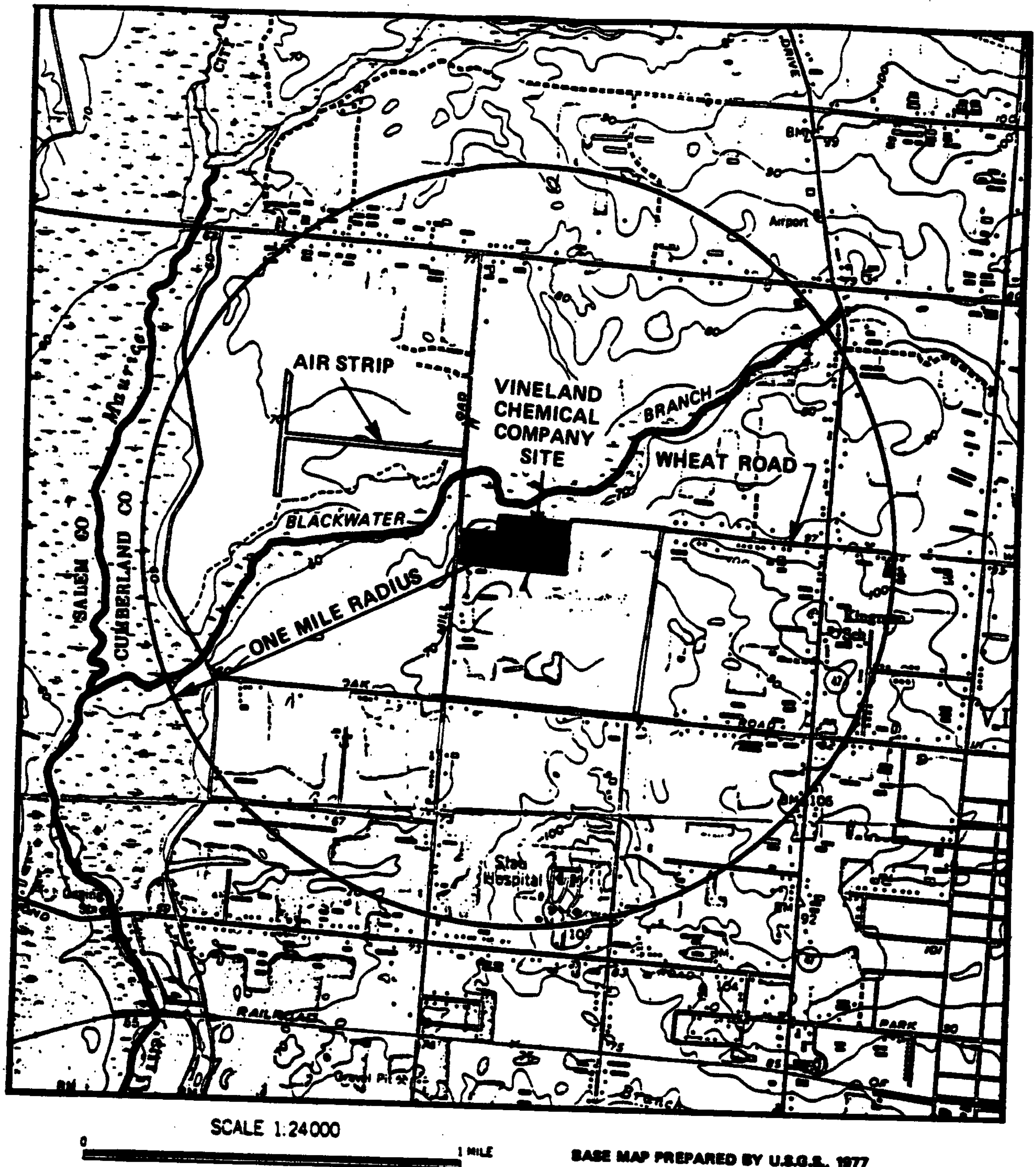
1.2.1 Site Description

The Vineland Chemical Company plant site is located in a residential/industrial area in the northwest corner of the City of Vineland in Cumberland County, New Jersey. The plant location is shown in Figure 1-3.

The plant is bordered on the north by Wheat Road and the Blackwater Branch, a tributary to the Maurice River. Residential areas border the plant to the east and south.

ViChem has produced organic herbicides and fungicides at this location since 1949. ViChem currently produces two major herbicidal chemicals, disodium methanearsonate and monosodium methanearsonate. Table 1-2 lists chemicals used, manufactured, or known to be stored at the ViChem plant site.

The ViChem plant site is shown in Figure 1-4. The plant consists of several manufacturing and storage buildings, a laboratory, a worker change facility, a wastewater treatment plant and several lagoons. The manufacturing and parking areas shown in Figure 1-4 are paved. The lagoon area is unpaved and is devoid of vegetation. This area is characterized by loose sandy soils. The remainder of the site is covered by trees, grass, or shrubs.



BASE MAP PREPARED BY U.S.G.S., 1977

U.S. ENVIRONMENTAL PROTECTION AGENCY
VINELAND CHEMICAL COMPANY SITE
FIGURE 1-3 VINELAND CHEMICAL COMPANY ONE MILE RADIUS
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TABLE 1-2

CHEMICALS USED, MANUFACTURED OR STORED AT VINELAND CHEMICAL PLANT

INORGANIC METALS AND SALTS

Arsenic
Mercury
Mercury (II) chloride
Mercury (I) chloride
Cadmium
Cadmium chloride

FLOCCULANTS

Aluminum
Iron

METAL ORGANIC ARSENIC COMPOUNDS

Disodium methanearsonate
Dodecyl and octylammonium methanearsonate
Monosodium acid methanearsonate
Calcium acid methanearsonate
Dimethylarsonic acid (Cacodylic acid)

ORGANIC MERCURY COMPOUNDS

Phenyl mercury dimethyldithiocarbamate
Phenyl mercuric acetate

HERBICIDES

Sodium 2,4-dichlorophenoxy acetate (2,4D)
2-4-dichlorophenoxy acetic acid
2-(4-chloro-2-methylphenoxy) propanoic acid (MCPP)

bis(dimethylthiocarbonyl)disulfide (thiram)

1,4-bis (bromoacetoxy)-2-butene
2,3-dibromopropionaldehyde

Alkylarylpolyether alcohol

SOLVENTS AND GENERAL ORGANIC CHEMICALS

Benzyl alcohol
Xylene
2,3 Benzofuran

Methanol
Epichlorolydrin
Acrolein
Isopropyl alcohol

Methyl chloride
Methylene chloride
Trichloroethane
Trichloroethylene

Tetrachloroethylene
Bromochloromethane

Methylene-bis-thiocymate
Hydrobromic acid

Tetrabutyl ammonium bromide
Bromo acetic acid

TABLE 1-2 (Cont'd)

CHEMICALS USED, MANUFACTURED OR STORED AT VINELAND CHEMICAL PLANT

Glycerine
Triton X-100
Formaldehyde
Butanediol

Gasoline
Kerosene

POSSIBLE CHEMICALS FROM MANUFACTURING

Phenol
Chlorophenols
Chloroacetic acid
Chlorides
Arsenic trioxide
Arsenic pentoxide
Methyl chloride
Methanol
Sodium hydroxide
Calcium oxides, chlorides, sulfates
Mercury oxides
Cadmium salts

Compiled from
1) Miller, F., NJDEP Memo, Vineland Chemical Ground Water Pollution Problem, May 24, 1985
2) Sittig, M., Pesticide Manufacturing and Toxic Materials Control Encyclopedia, Noyes Data Corp., Park Ridge, NJ (1980)

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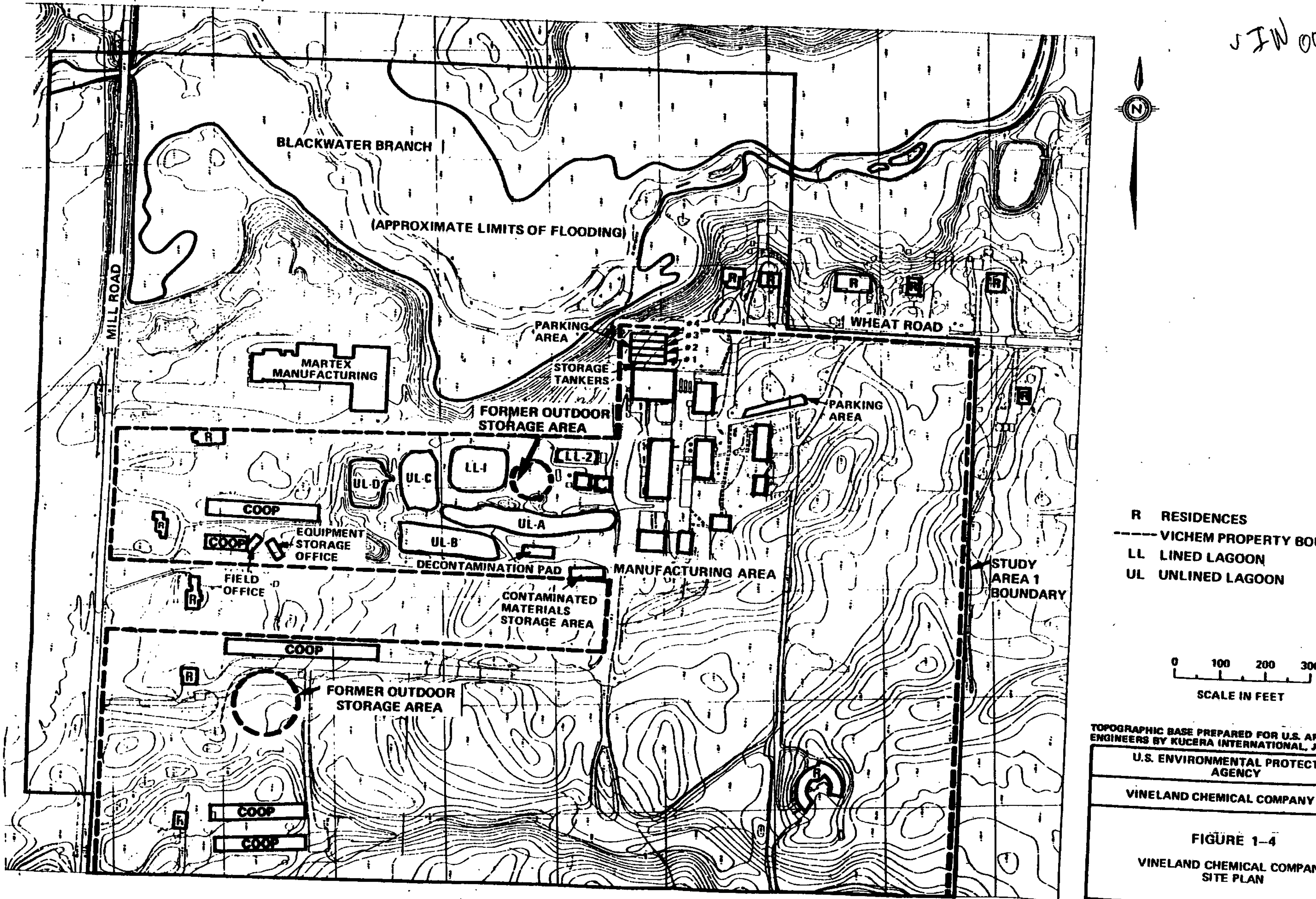

TOPOGRAPHIC BASE PREPARED FOR U.S. ARMY CORPS OF ENGINEERS BY KUCERA INTERNATIONAL, JANUARY

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1–4

VINELAND CHEMICAL COMPANY SITE PLAN

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The site is situated in a residential/industrial area. Twelve residences are shown in Figure 1-4 in the immediate vicinity of the plant. A number of other residences are located close to the plant along Wheat, Orchard, Oak, and North Mill Roads, as shown in Figure 1-5.

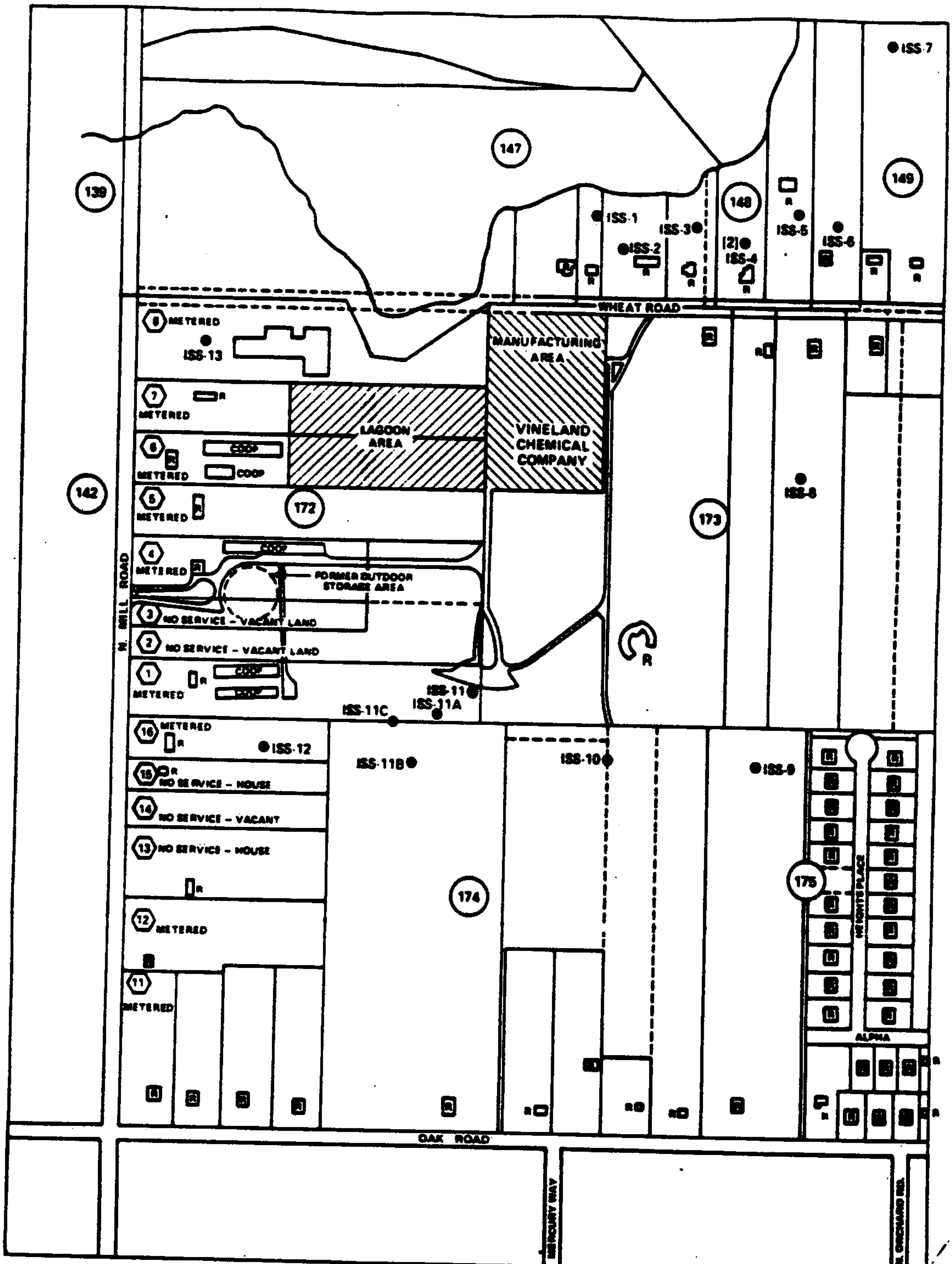
The Martex Manufacturing facility is located immediately north and west of the ViChem lagoon area. Martex reportedly produces packaging materials, although little information is available on the materials used or manufactured at this site.

The Blackwater Branch is immediately north of the ViChem plant site, as shown in Figure 1-6. This stream flows east to west and discharges into the Maurice River approximately 1.5 river miles downstream from the plant. The upper Maurice River, shown in Figure 1-7, then flows approximately 7 river miles downstream into Union Lake, which is approximately 2 miles long. The Maurice River then flows approximately 25 river miles downstream from the lake into the Delaware Bay, as shown in Figure 1-8.

Some time between April 1985 and June 1986, beavers constructed a dam on the Blackwater Branch just downstream from the North Mill Road bridge. The dam flooded the Blackwater Branch to the approximate extent shown in Figure 1-4. The dam was removed in October 1987 to allow for construction of a new bridge. The Blackwater Branch is now flowing in its normal channel and the flooded areas have been drained.

A wastewater treatment system is in operation at the ViChem plant. The system has a design capacity of approximately 25 gallons per minute (gpm), or 36,000 gallons per day (gpd), assuming 24 hours of operation. The system was designed to treat between 2,000 and 5,000 gpd of process water, 20,000 gpd of groundwater, which was to be pumped from the shallow water table, and storm runoff water as necessary. In addition, provisions were made to collect up to 60,000 gpd of non-contact cooling water in the event that a mechanical breakdown occurred and mixed the non-contact cooling water with the contaminated process water.

The wastewater treatment system consists of mix tanks, a reactor, filters and ancillary equipment. Ferric chloride is added to the first flash mix tank and caustic soda is added to the second mix tank to promote flocculation. The wastewater then enters the reactor where it is mixed with a polymer. This mixture then passes through a flocculation compartment where the large particles settle to the bottom and are removed to a rubber-lined tank. The reactor effluent is polished by a tertiary filter before discharge. The slurry in the rubber-lined tank is pumped into a vacuum filter and the dry solids are deposited in a dumpster for off-site disposal. Any liquid not meeting discharge requirements is reportedly recirculated for treatment.



LEGEND:

172	BLOCK NUMBER
●	SOIL SAMPLING LOCATIONS
R	RESIDENCES
⬡	LOT NUMBER

NORTH

0 200 400 600 800

SCALE IN FEET

BASE MAP PREPARED BY CITY ENGINEER, WILLIAM G. AUSTIN, CITY OF VINELAND, OCTOBER 1971.

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1–5

RESIDENTIAL SOIL SAMPLING LOCATIONS AND WATER SUPPLY ALONG N. MILL ROAD

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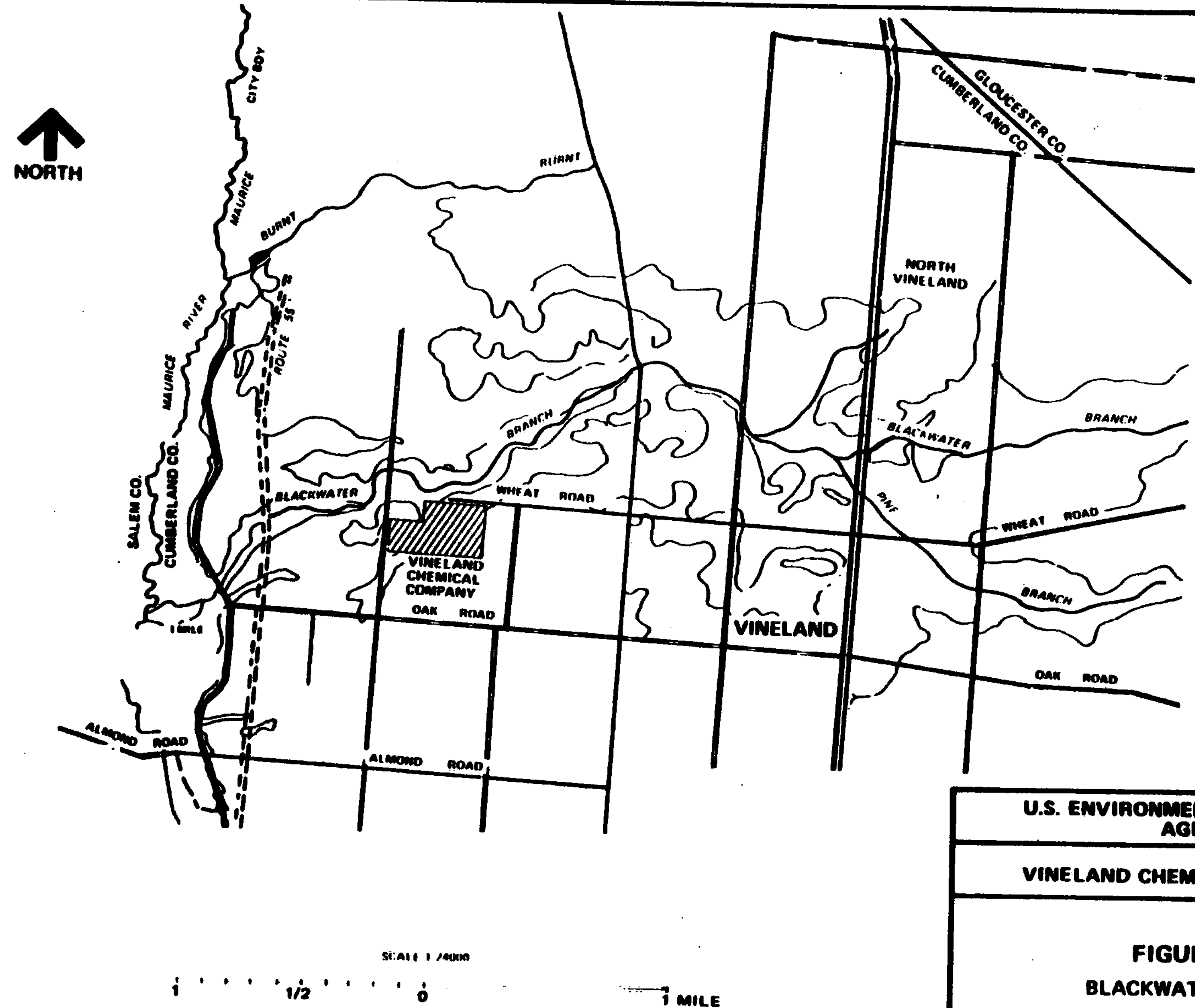

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1–6
BLACKWATER BRANCH

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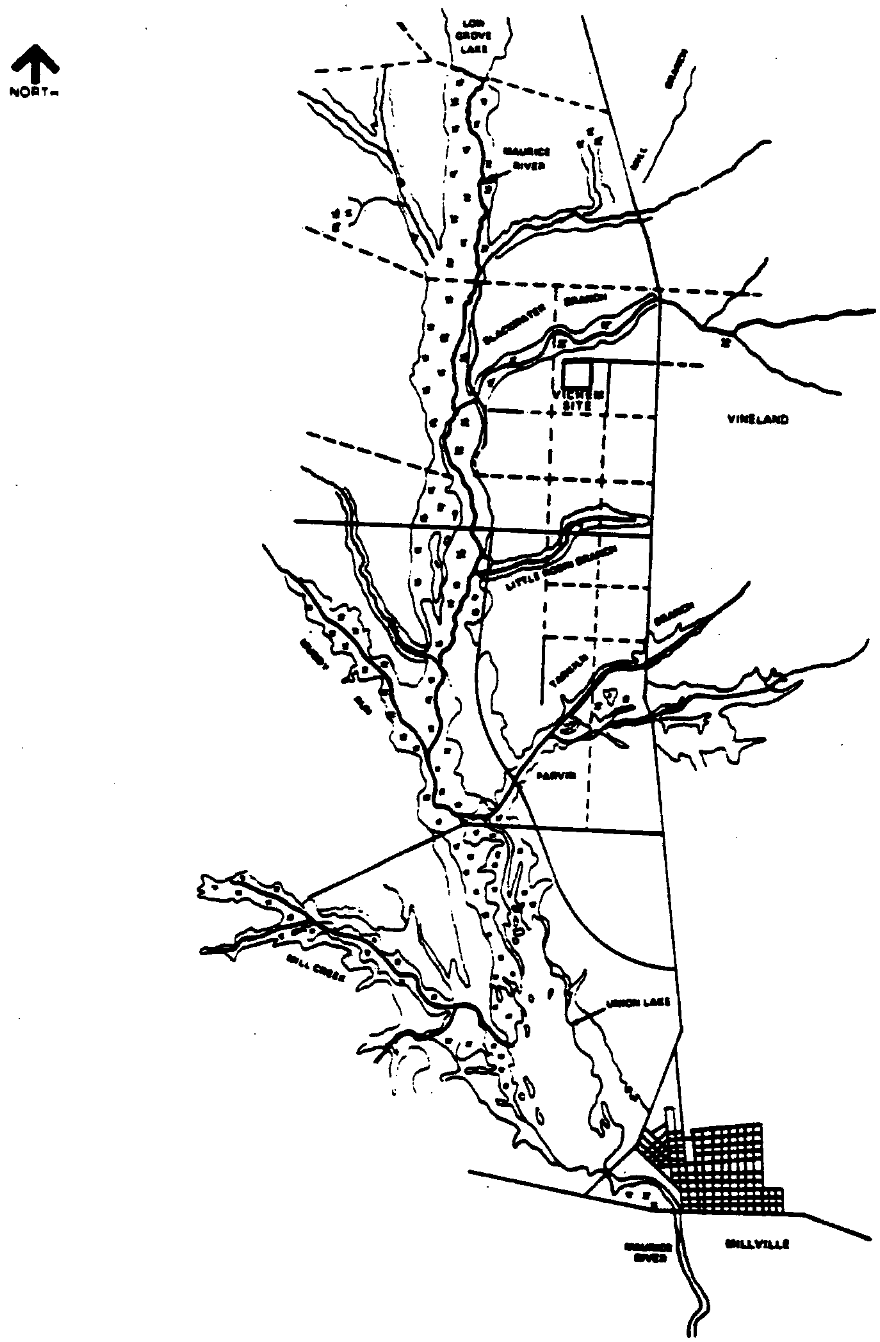

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1–7

MAURICE RIVER NORTH OF UNION LAKE

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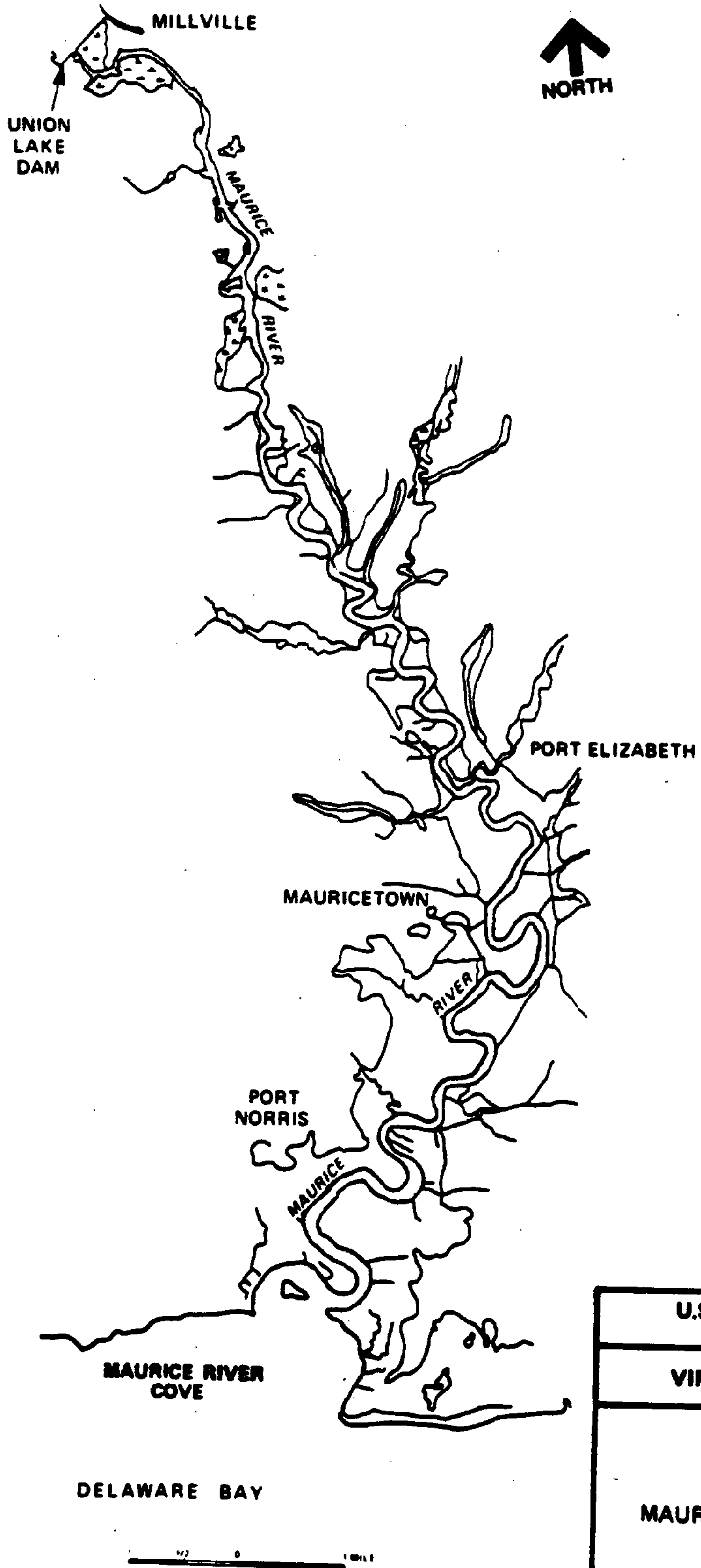
VIN 002 0244



U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SIT

FIGURE 1–8

MAURICE RIVER SOUTH OF UNION LA

EBASCO SERVICES INCORPORATI

VIN 002 0245

Some of the lagoons shown in Figure 1-4 are used in the wastewater treatment system. Lagoon LL-1 is a lined lagoon with a 490,000-gallon capacity. This lagoon was designed to hold process water, groundwater and storm water as necessary prior to treatment. Water can be pumped from this lagoon to the plant at 25 gpm. Lagoon LL-2 is also a lined lagoon but it has a concrete base. It was previously used to store the arsenic contaminated waste salt K 031 produced as a byproduct of the herbicide manufacturing process, and later was used to hold the treatment plant sludge prior to disposal. It now holds water to be recirculated for retreatment. Lagoon UL-A is an unlined lagoon. This lagoon receives the non-contact cooling water and the treated discharge from the treatment plant. Because the site soils are sandy and this lagoon is unlined, inflow into the lagoon rapidly infiltrates the groundwater.

The remaining lagoons shown in Figure 1-4, UL-B, UL-C, and UL-D, are all unlined and are not currently used in the water treatment system. However, aerial photographs provided by the USEPA's Environmental Photographic Information Center (EPIC) used in the USEPA's Site Analysis, Vineland Chemical Company (Simpson, 1988) show that UL-A, UL-B, UL-C, UL-D and LL-1 (which was previously unlined) were connected to one another in the past. The photographs show that all of the lagoons were filled with liquid.

The two lined lagoons, LL-1 and LL-2, are regulated by RCRA. The wastewater treatment plant and the unlined lagoon, UL-A, are regulated under the NJPDES program. Other active solid waste management units at the plant site include the trailers/tote bins used to store K 031 waste salts and treatment plant sludge, septic system and leachfield, and the soil beneath the floors of the production buildings where past operating procedures reportedly produced spillage. Inactive/abandoned solid waste management units are basically areas where waste salts were improperly stored in the past, including the waste salt piles, sludge piles, chicken coops, and outdoor drum storage areas.

The treatment plant was designed to produce an effluent with an arsenic concentration of 0.05 milligrams per liter (mg/l). ViChem initially had difficulties achieving this level. Therefore, an interim standard of 0.7 mg/l was agreed to and ordered by NJDEP in December 22, 1981, with the understanding that the 0.05 mg/l level would eventually be met. Results from in-house tests performed daily by ViChem indicate that the effluent has been reduced to below the interim standard, but the levels are still greater than 0.05 mg/l when the influent concentrations are high, but are less than 0.05 mg/l when the influent concentrations are low.

ViChem reports that it no longer treats either groundwater or process water. Reportedly, all of the water used in manufacturing the herbicides is consumed by the process and is included as inherent moisture in the product. ViChem ceased pumping and treating groundwater in July 1987 with the consent of the NJDEP. One of the reasons the NJDEP allowed ViChem to stop pumping and treating the groundwater was the NJDEP's concern that the treatment plant effluent, whatever its arsenic concentration, would cause a groundwater mound, driving existing groundwater contamination deeper into the groundwater and promoting off-site migration. The wastewater treatment plant now reportedly treats only storm water runoff intermittently.

The herbicide manufacturing process produces approximately 1,107 tons of waste by-product salts each year. These wastes have a USEPA hazardous waste number of K 031 and are neither treated nor disposed of at the site, and are not stored on-site for more than 90 days. The salts are transported by licensed shippers to licensed facilities in Ohio and Michigan for disposal.

1.2.2 Site History

ViChem began manufacturing organic arsenical herbicides and fungicides at this plant in 1949. In addition to arsenical herbicides, the company also produced cadmium-based herbicides and used other inorganics such as lead and mercury. Table 1-2 presented a list of chemicals used, manufactured or stored at the ViChem plant site.

As early as 1966, the NJDEP observed ViChem discharging untreated wastewaters with unacceptable arsenic concentrations (67 mg/l) into the unlined lagoons. An unknown quantity of arsenic rapidly infiltrated the groundwater from the lagoons. On February 8, 1971, ViChem was ordered to install and provide industrial wastewater treatment and/or disposal facilities. The wastewater treatment works did not become operational until March 1980.

Waste salts from the herbicide production process were stored on-site in uncontrolled piles on the soil, in the concrete lagoon LL-2 (which at the time was unlined), and in abandoned chicken coops on the plant property. The storage of salts in piles was observed in April 1970 and in the coops in April 1973. It was not until 1978 and many court orders that the salts were containerized and removed. These salts reportedly contained one to two percent arsenic (RCRA Part B Permit Application, 1980). As these salts have a high solubility, precipitation contacting these piles rapidly dissolved the salts and carried an unknown quantity of arsenic into the groundwater.

Between 1975 and 1976, ViChem was fixating the waste salts for disposal at the Kin-Buc Landfill. The process involved mixing the dried salts with ferric chloride and soda ash, reportedly reducing the solubility. The process was stopped in 1976 when the Kin-Buc Landfill voluntarily stopped accepting all chemical wastes, including the fixated salts. ViChem then resumed piling the untreated waste salts on the soil surface at the plant site.

A court order issued on January 26, 1977, required ViChem to containerize the waste salts from the chicken coops and piles, and then store the drums in a warehouse off-site. In June 1979, another order was issued for the disposal of the stored drums in an approved landfill. Removal and disposal of these drums was not completed until June 30, 1982.

Currently the waste salts and the sludge from the wastewater treatment systems are stored in large-capacity trailers and tote bins. The tote bins are filled at the point of generation in the manufacturing buildings, and then emptied into the trailers. The NJDEP believes that releases are unlikely from this system. The salts and sludge are transported to licensed facilities as mentioned above. During peak production, as many as four or five trailers are filled and removed per week.

Aerial photographs provided by the USEPA's Environmental Photographic Information Center (EPIC) and conversations with ViChem employees indicated several possible locations of past contamination. The cleared area in the southwest corner of the site shown as a "former outdoor storage area" in Figure 1-4 was at one time occupied by two chicken coops. Sometime between November 1975 and March 1979, both coops were destroyed. These coops were reportedly used to store process chemicals and/or waste. The materials stored in the coops may have percolated into the groundwater. This area is now devoid of vegetation. Photographs also show many other locations containing mounded material and/or drums. These include the lagoon area and locations along the plant road. The waste salts were reportedly mounded so high at times beyond Lagoon LL-2 that the salts spilled over onto the soil in the lagoon.

It is alleged that the floors of the manufacturing plant have been leaking arsenic compounds into the underlying sands for years. The original floors of the buildings were brick and were allegedly in need of repairs several years ago. Allegedly, when the old bricks were removed, the soil contained crystalline wastes from previous spills. It is not known whether the soils were removed when the floors were replaced, although in Ebasco's Phase II investigation the soils below building #9 were sampled and had high arsenic concentrations (see Section 4.0 of the Plant Site RI). The floor of the building was solid and in good repair during Ebasco's 1987 investigation.

In response to a series of Administrative Consent Orders issued by the NJDEP, ViChem instituted some cleanup actions and modified the production process. The cleanup actions included stripping the surface soils in the manufacturing area, piling these soils in the clearing by well cluster EW-15, and paving the manufacturing area; installing a storm water runoff collection system; removing the piles of waste salts; and installing a groundwater pump and treat system, including the wastewater treatment plant.

Modifications to the production process included installing a water system where mixing of process water and non-contact cooling water was unlikely, lining two of the lagoons used in the wastewater treatment system (LL-1 and LL-2), and properly disposing of the waste salts.

The evidence described above suggested that a serious groundwater contamination problem existed at the ViChem plant site, and that the groundwater was discharging into the streams and degrading the downstream water quality. This RI/FS was undertaken to investigate the extent of contamination and to evaluate remedial alternatives for rehabilitating the groundwater, soil, downstream sediments and surface waters.

1.2.3 Permit Actions

On December 2, 1985, the USEPA informed ViChem that its interim status for the lined RCRA impoundments was terminated as a matter of law on November 8, 1985 because of failure to comply with Section 3005(e)2 of RCRA. The USEPA determined that the company: (a) failed to certify compliance with the applicable financial assurance requirements for closure and post-closure care; (b) failed to certify that required liability insurance was ever actually obtained; and (c) failed to certify the preparation of a groundwater monitoring program meeting the requirements applicable to interim facilities. The company was to cease placing hazardous waste into the two lined lagoons.

ViChem submitted applications for RCRA and NJPDES permits. The RCRA permit application was for storage of hazardous wastewaters in the two lined lagoons. The NJPDES discharge to groundwater permit application was for discharge of non-contact cooling water to the unlined lagoon UL-A.

In April, 1986, the NJDEP advised ViChem of its intent to deny both the RCRA and NJPDES permits. The technical and administrative bases for the tentative decision to deny the NJPDES permit were: (a) the discharge of 200,000 gallons per day (gpd) of non-contact cooling water into the unlined lagoons increased hydraulic gradients, thereby forcing contaminated groundwater deeper into the aquifer and further off-site; and (b) the treatment works were unable to meet the discharge criterion of 0.05 mg/l for arsenic. The technical bases for denying the RCRA permit application were inadequate closure, post-closure, and liability assurance requirements, and an inadequate groundwater monitoring program. The administrative basis for denial was the failure to submit a complete hazardous waste facility permit application, given adequate time to do so. The NJPDES permit denial is being appealed by ViChem.

VIN 002 0249

1.2.4 Previous Investigations

Since 1978, a number of studies have been performed by or for the NJDEP Office of Science and Research in the Maurice River watershed and at the ViChem plant site. ViChem itself has also conducted some investigations into the groundwater plume at the plant.

In the years 1979 to 1980, the NJDEP initiated a sampling program in the Blackwater Branch and the Maurice River downstream from the site. The results showed that the sediment arsenic concentrations in the Maurice River were the highest seen anywhere within the State of New Jersey. The study showed that the Almond Beach weir, the submerged dam in Union Lake, the lower main dam in Union Lake, and the tidal creeks of the Maurice River estuary below Union Lake contained arsenic-contaminated sediments. Elevated arsenic concentrations were found in sediments as far from the site as the Delaware Bay, approximately 36 river miles downstream from the site. Also, the arsenic concentration in the surface water decreased downstream from the site but did not reach the Federal Primary Drinking Water Standard for arsenic, 0.05 mg/l or 50 ug/l, until 26.5 river miles downstream from the ViChem plant site.

In 1978, ViChem commissioned a surface geophysical survey of the site at the direction of the NJDEP. The survey noted that areas of probable contamination were the lagoon area, the area north of the lagoons to the Blackwater Branch, the former outdoor storage area shown in Figure 1-4, and areas along the plant road between the former outdoor storage area and the lagoons. The report also contended that the probable groundwater contamination was shallow and recommended locations for installing extraction wells.

In 1979, NJDEP sampled soils in the ViChem plant site area. Samples were taken at the surface and at depth. The study showed arsenic concentrations ranging from undetected to 864 mg/l at various locations in the plant site area.

In 1981, the NJDEP performed a surface geophysical survey of the plant area. The study identified two areas of probable groundwater contamination, one northwest of the lagoons toward the Blackwater Branch and the other near the former outdoor storage area. The study estimated that the probable maximum depth of the contaminant plume was approximately 40 feet.

In 1982, ViChem commissioned a groundwater investigation of the plant site. In this study, previous investigations were reviewed and a scheme to remove arsenic from the contaminated aquifer was proposed. This study included several sets of water quality data. Approximately 4-1/2 years of monthly arsenic concentrations at ViChem well MW-1 were presented along with data from ViChem wells MW-6 and MW-10. These data showed a marked drop in the arsenic concentration in the groundwater between 1978 and 1981. The study also presented monthly levels of arsenic in the Blackwater Branch at North Mill Road, and in the Maurice River at the Almond Road weir. The study postulated that the arsenic load at North Mill Road was very similar to the arsenic load at Almond Road, implying that the river system was, essentially, a conduit for arsenic transport into Union Lake. The study reviewed processes for arsenic cleanup at the site and recommended a groundwater pump and treat program along with controlled soil leaching.

In 1982, an employee of ViChem was diagnosed as having subacute arsenic poisoning. The New Jersey Department of Health then conducted a "Cross-Sectional Evaluation of Arsenic Exposure and Toxicity at the Vineland Chemical Company." The study revealed that employees had elevated arsenic concentrations in their hair and urine, but only exhibited minor symptoms associated with arsenic trioxide dust on the skin and mucous membranes. As a result of this survey, the arsenic-handling practices in the production facility were improved.

Two studies were conducted by the NJDEP and Rutgers University from 1980 to 1982 in Union Lake. The studies showed that Union Lake is chemically stratified during the summer. This stratification creates seasonal anaerobic conditions in the bottom sediments, which are conducive to the formation of toxic arsenical compounds from the contaminated sediments (NJDEP, 1986). The Rutgers University work included sampling and analysis of water and sediments, as well as speciation of arsenic [trivalent-As (III), pentavalent-As (V), monomethyl arsenic acid (MMAA) and dimethyl arsenic acid (DMAA)(Faust, 1983)]. This study concluded that the waters and bottom sediments were highly contaminated with substantial quantities of arsenic, and that total arsenic concentrations in all lake water samples exceeded the NJDEP and USEPA drinking water standard of 50 ug/l. In sediments, the order of predominance of the four arsenic species (in descending order) was: As (V), As (III), MMAA, DMAA. In four of the sediments, the inorganic arsenate was between 73% and 88% of the total arsenical species. In water, the order of predominance was MMAA, As (III), As (V), DMAA. The results of the resampling efforts revealed a seasonal pattern of arsenic concentrations within the lake water with the greatest concentrations occurring during the summer. Additional NJDEP sediment sampling near the spillway area of Union Lake in April 1986 again showed arsenic contamination within the sediments and showed that contamination within the sediments was a surficial phenomenon.

In a 1983 to 1985 study by Rutgers University (Winka, 1985), it was shown that arsenic may exist in many species in the watershed, and that these species may be transformed by changes in physical condition and season. Results indicated that within the water column, the inorganic arsenic species may be one half of the total arsenic. Arsenic was not easily solubilized under aerobic conditions. The concern raised by these findings is that when an anaerobic condition develops on the bottom of Union Lake, the arsenic would be readily converted into the more toxic As (III) and As (V) forms. The more toxic forms could then be released to the water column upon seasonal turnover of the stratified layers. However, as these compounds are relatively insoluble, they are expected to precipitate back to the lake bottom within a relatively short period of time.

In 1982, ViChem commissioned a pumping test to be performed on the shallow aquifer underlying the lagoon area. The pumping test estimated a transmissivity in the shallow aquifer of approximately 50,000 gpd/ft, and a storage coefficient of between 0.1 and 0.04.

In 1985, ViChem's RCRA Part B permit application was submitted to the NJDEP. The application included a description of the wastewater and groundwater handling, and a description of the wastewater treatment process and facility design. The application also included data on the production rates at the plant and the toxicity of the wastes generated. Arsenic concentrations in the Blackwater Branch through time were also presented.

In 1986, ViChem commissioned a pumping test to be performed in the deeper groundwater below the site. The plant's production well, screened from 130 to 165 feet below the ground, was used as the pumping well and a deep monitoring well was installed in the lagoon area. The pumping test was conducted for 24 hours, with water levels measured in the deep monitoring well and several shallow monitoring wells near the discharge in the lagoon area. The report concluded that the "clay layer," reportedly encountered from 120 to 135 feet below the ground and which the production well is screened below, acts as a confining layer and prevents downward migration from the overlying aquifer. However, Ebasco's review of this pumping test data revealed that there was significant leakage across this "clay layer" during the pumping test.

The USEPA's Environmental Photographic Information Center (EPIC) produced a report in March 1988 on the ViChem plant site. The report presents an aerial photographic analysis of the ViChem plant site and surrounding area. The first photograph presented was taken in March 1951 and the last was taken in November 1987. A total of 11 photographs were presented in the report.

Among other things, the analysis of the photographs shows areas of "Vegetation Damage" and "Vegetation Stress" along the Blackwater Branch beginning with a September 1979 photograph. None of the prior photographs show vegetation damage or stress, and all of the later photographs show some vegetation damage and/or stress.

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Some of the damaged areas are in the portion of the Blackwater Branch, which was inundated with water from the beaver dam. However, the beaver dam was not constructed until some time after April 1985, much later than the first indication of vegetation damage/stress. A topographic base map for the site that was flown in April 1985 shows the Blackwater Branch flowing in its normal channel at that time. It should be pointed out that the damaged/stressed areas are coincident with the contaminated groundwater plume coming off the ViChem plant site.

In 1988, the USEPA's Environmental Response Branch prepared a bioassessment on the Blackwater Branch and the upper Maurice River. The report concluded that there was an adverse impact to the benthic communities in the Blackwater Branch downstream from the ViChem plant site. The impact takes the form of lower species diversity and a toxic response in bioassay tests done with the sediments. The impact lessens in the Maurice River, probably resulting from dilution.

In addition to the above studies, Ebasco, under contract with the USEPA, prepared RI reports for three portions of the ViChem plant site: the ViChem plant area (Ebasco, 1989a), the River Areas north of Union Lake (Ebasco, 1989c) and Union Lake (Ebasco, 1989e). Pertinent findings from these RI reports are as follows:

- There is a heavily contaminated arsenic plume in the shallow groundwater underneath the site within an aquifer termed the upper sand in the plant RI report. No arsenic contamination was seen below the base of the upper sand, ranging from 40 to 70 feet below the ground surface. A unit termed the banded zone, which contains clay laminae, was found at the base of the upper sand and apparently prevents the downward migration of arsenic.

- The groundwater in the upper sand discharges into the Blackwater Branch and, thus, provides the arsenic flux into this stream and the Maurice River.

- The arsenic flux in the groundwater was estimated at 6 metric tons per year in 1987. It was estimated that a total of approximately 500 metric tons of arsenic has been transported off the site through time.

- The Blackwater Branch floodplain is contaminated with substantial quantities of arsenic. This area was previously inundated with floodwaters from the beaver dam. The dam was breached and the area is now exposed. The exposed floodplain sediments contain very high arsenic concentrations in places (up to 4,000 mg/kg).

- The Blackwater Branch and the upper Maurice River basically behave as conduits, transferring arsenic from the plant site into Union Lake. The inventory of arsenic bound to the sediments was estimated to be approximately six metric tons. This arsenic was apparently bound to fines and organics in the sediments.

- Union Lake is contaminated with substantial quantities of arsenic, with a mean dissolved arsenic concentration in the water of approximately 56 ug/l, which is above the 50 ug/l Federal Primary Drinking Water Standard for arsenic. The mean arsenic concentration in the sediment is approximately 74 mg/kg, significantly higher than the background arsenic concentration in the Maurice River above the confluence with the Blackwater Branch which is less than 2 mg/kg. The highest arsenic concentration detected in the sediments was over 1,200 mg/kg. It was estimated that approximately 140 metric tons of arsenic was bound to Union Lake's sediments.

- The controlling factor for the lake's water arsenic concentration could not be determined. On one hand, the arsenic concentration in the water coming in, within and flowing out of the lake was approximately the same. This suggests that the upstream arsenic concentration controls the lake's arsenic concentration. On the other hand, the lake water and sediments were apparently in equilibrium, based on the sediment arsenic concentration, the water arsenic concentration, and the partition coefficient. Since the predicted equilibrium concentrations were approximately equal to the incoming water concentration, the controlling factor for the lake's water concentration could not be determined.

- The Maurice River below Union Lake had elevated sediment and water arsenic concentrations. The water arsenic concentration did not fall below 50 ug/l until approximately 10 miles downstream from the lake (26.5 miles downstream from the plant). The water concentration dropped sharply when the tidal front was reached. The arsenic inventory in the sediments could not be determined; however, it was established that possibly as much as half of the arsenic released off of the site was stored in the lower Maurice River sediments.

- It was estimated that if the source of arsenic into the watershed (groundwater discharge off of the ViChem plant) were stopped, the water arsenic concentration in the Blackwater Branch and the upper Maurice River would drop relatively quickly. These portions of the watershed are believed to act as conduits for the arsenic flux and do not bind substantial quantities of arsenic relative to the lake. It was also estimated that if the source of arsenic were eliminated the lake water's arsenic concentration would drop, although how much and how quickly was not known. Arsenic may continue to desorb from the sediments and maintain a somewhat elevated arsenic concentration in the future. At a minimum the concentration should not increase over what is present now and the present concentration is close to the MCL of 50 ug/l.

1.2.5 Community Concerns

In 1984, after the ViChem site was added to the National Priorities List, USEPA implemented a community relations program to inform area residents about the Superfund-related activities and to obtain their input. Community concern increased from moderate to relatively high and also became more specific. The involvement of organized environmental groups generated media attention and increased public awareness of the site.

As a result of USEPA's community relations activities, five major community concerns were identified:

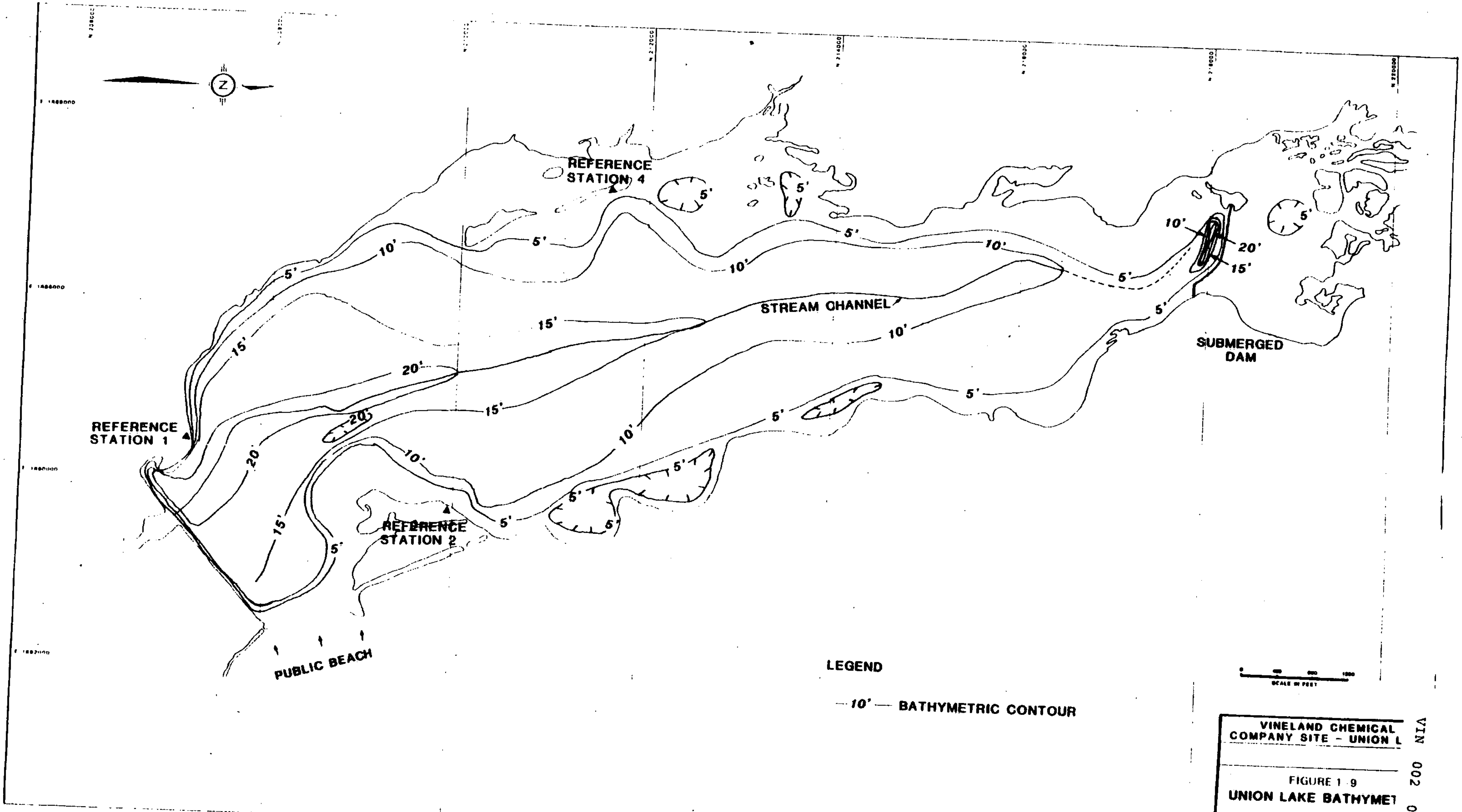
- Human health risks from exposure to contaminated groundwater because some of the residents relied on groundwater for potable water;
- Human health risks from exposure to contaminated surface water because local rivers and lakes are used for recreation;
- Frustration over the perceived lack of remedial action at the site;
- A perceived lack of cooperation on behalf of ViChem during the remedial response process; and
- A perception of inadequate information from the NJDEP.

1.3 SUMMARY OF THE RI REPORT

The RI report for Union Lake was submitted to the USEPA in June 1989. The major findings of the RI as they relate to this FS are summarized below.

1.3.1 Physical System

A bathymetric survey of the lake was performed for the RI. Bathymetric contours are shown in Figure 1-9. The lake is typically shallow, especially at the upstream northern end. There is a submerged dam at the northern end of the lake. A relatively deep hole exists just downstream of this submerged dam, as shown in Figure 1-9.



VINELAND CHEMICAL COMPANY SITE - UNION L

FIGURE 1-9
UNION LAKE BATHYMET

EBASCO SERVICES INCORPORA

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The main dam at the southern end of the lake is currently undergoing reconstruction. The dam was assessed to pose a safety hazard because the spillway was inadequate to pass the probable maximum flood (PMF) resulting from various rainfall events.

Prior to the reconstruction project, the lake's normal pool elevation was approximately 27 feet MSL. The actual pool elevation varied according to flow. The estimated flow out of the lake is 325 cfs (experienced 50% of the time), which produced the 27 feet MSL pool elevation.

To facilitate the dam rehabilitation, a section of the spillway was breached to lower the lake's water level. The breached section has a bottom elevation of approximately 16 feet MSL. The depth of water flow over the breached section is approximately 2.2 feet at the median 325 cfs flow, resulting in a normal pool elevation of approximately 18.2 feet MSL. Therefore, the lake's elevation has been lowered between 8 and 9 feet for reconstruction.

The new spillway will be approximately 200 feet wide and will have a bottom elevation of 26.67 feet MSL. At the median flow of 325 cfs, the lake's pool elevation will be approximately 27 feet MSL. Six new low level outlets will be provided, three at an elevation of 16 feet and three at an elevation of 11 feet MSL. The outlets can be used to pass high flows or to artificially lower the lake's water level if desired.

The NJDEP's Division of Fish, Game, and Wildlife is the using agency for the reconstruction project and will control the operation of the spillway. They can lower the water level, for example, if they decide to control bottom growth through partial draining to expose bottom areas, thus allowing vegetation to freeze and die before refilling the lake.

Detailed studies of the lake's inflow versus its outflow have not been performed. However, PRC Engineers, the company performing the dam reconstruction project, estimates that the lake outflow is approximately twice the flow volume at the USGS gaging station on the Maurice River at Norma, approximately four miles upstream.

The lowest flow recorded at Norma since the gage began operating in 1932 is 23 cfs. Since there has always been recorded flow at the Norma gage, and since it is believed that the Maurice River is an effluent stream (recharged by groundwater), it is assumed unlikely that even prolonged droughts would cause a lowering of the lake's water level below the spillway.

There is very little groundwater information available in the vicinity of Union Lake for determining if the lake could impact local groundwater supplies. However, the City of Millville derives its municipal groundwater supply from seven wells. All of these wells are at least one mile away from the lake. Millville's water system is periodically tested for arsenic and levels have been acceptable.

1.3.2 Nature and Extent of Contamination

The sediment in Union Lake is contaminated with arsenic and is extremely heterogeneous in physical and chemical composition. The percent of sand and silt varied greatly between samples collected in close proximity to one another. Similarly, the arsenic concentrations in collected samples varied by orders of magnitude.

Arsenic contamination, as evidenced by the core sample analytical results, is a surficial phenomena, present in the first one foot of the Union Lake sediments. Concentration levels ranged from not detected to 1,273 mg/kg, with the greatest levels occurring within the northern portion of the lake. Figure 1-10 presents the results of sediment samples taken by the NJDEP and Ebasco in 1986.

The results of the Union Lake sediment and water sampling are shown in Table 1-3. The analyses indicated that trace metals were usually present only in the water samples collected at the bottom of the water column, at the sediment-water interface. This suggests that these metals are associated with resuspended bottom sediments. The lake water contains total arsenic in the range of 10 to 190 ug/l distributed almost evenly among the upper-lake, mid-lake and lower-lake, particularly for the dissolved arsenic in the range of 10 to 80 ug/l. The mean total arsenic concentration, approximately 56 ug/l, is slightly above the Federal Primary Drinking Water Standard for arsenic, 50 ug/l.

The arsenic concentration in the Union Lake water apparently exhibits seasonal fluctuations. The greatest concentrations occur in summer and early fall, and the lowest concentrations occur in winter. This seasonal variability in arsenic concentrations is supported by several studies. Resuspended lake sediment can cause elevated arsenic concentrations, particularly close to the bottom and in highly turbid areas of the lake (i.e., adjacent to where the Maurice River enters the northern portion of the lake).

The results of the fish analyses are presented in Table 1-4. Among the fish caught, chlordane (5-72 ug/kg), DDE (63-160 ug/kg), PCB 1260 (120-400 ug/kg), and arsenic (20-240 ug/kg) were found to be present. The results indicate that the greatest concentrations of each chemical compound were generally present within bottom feeding (i.e., catfish) and piscivorous species (i.e., pickerel).

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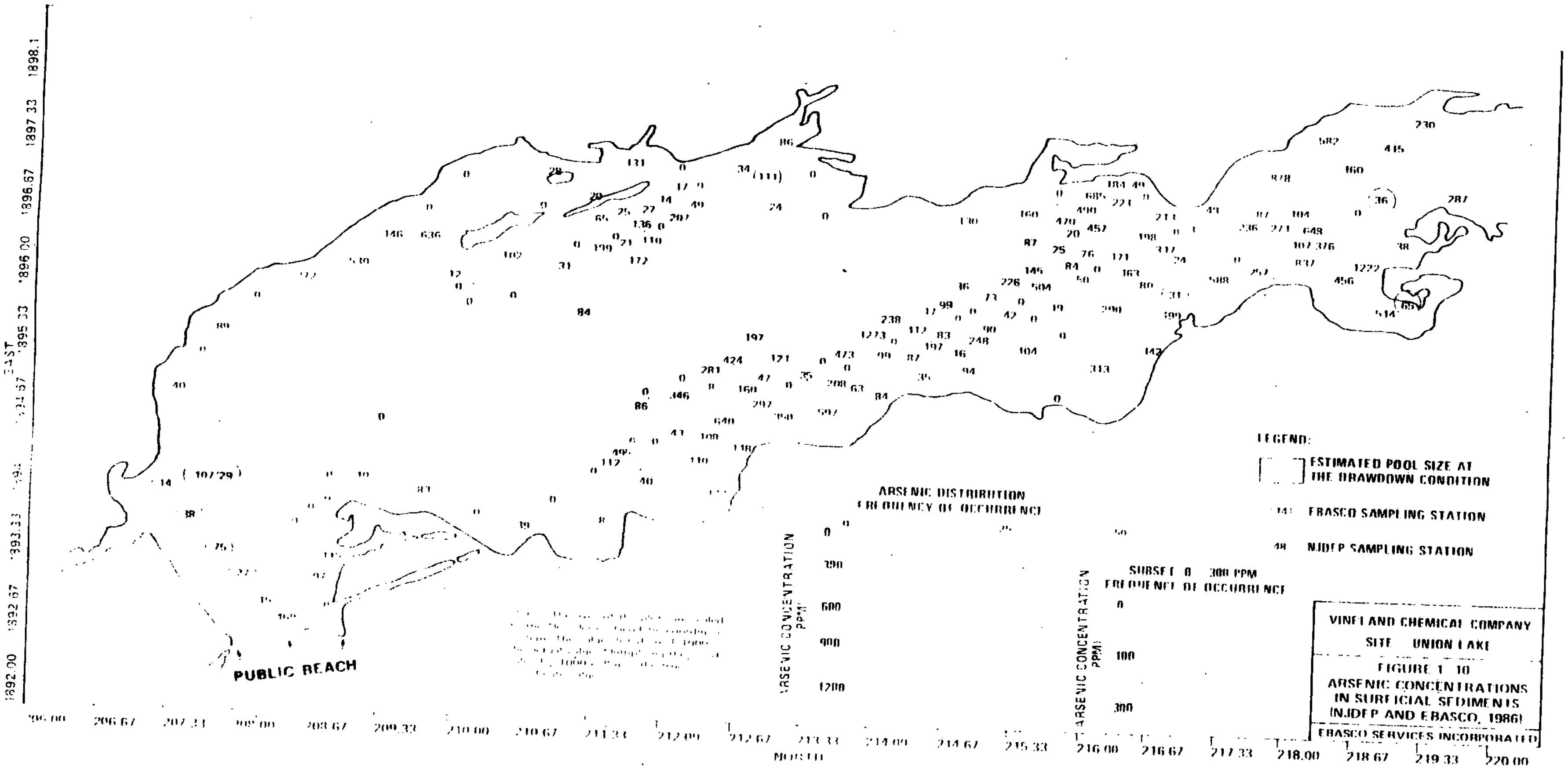

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TABLE 1-3

CONCENTRATION RANGES (mg/kg) OF TOTAL ARSENIC LEVELS IN UNION LAKE SEDIMENT SAMPLES

	Total As
NJDEP SAMPLING (August, 1986)	
Lakeshore sediments in less than 10 feet of water (193 sample locations)	0 - 1273
PHASE I (June - July, 1986)	
Upper-Lake sediment (EL-1, EL-2)	36 - 65
Mid-Lake sediment (EL-5)	12
Lower-Lake sediment (EL-9 through 13)	14 - 107

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TABLE 1-3 (Cont'd)

CONCENTRATION RANGES (ug/l) OF TOTAL AND DISSOLVED ARSENIC LEVELS IN UNION LAKE WATER SAMPLES

Particulate As	Dissolved As	Total As
NJDEP (September, 1982-1983)		
Upper-Lake water	-	36 - 267
Mid-Lake water	-	27 - 100
Lower-Lake water	-	33 - 194
PHASE I (June - July, 1986)		
Upper-Lake water (EL-1, EL-2)	44(R) - 50(R)	65(R) - 66(R)
Mid-Lake water	48 - 67	54 - 81
Lower-Lake water (EL-9 through EL-13)	48 - 75	54 - 81
PHASE II (January, 1987)		
Upper-Lake water (EL-28 through EL-30)	21 - 41	20 - 187
Mid-Lake water	10 - 22	11 - 26
Lower-Lake water (EL-9 through EL-13)	14 - 16	12 - 126

(R) - Rejected value

TABLE 1-4

ARSENIC, PESTICIDE AND PCB RESULTS
FOR FIVE FISH SPECIES (ug/kg)
(January, 1987)

Organism	Chlordane	4,4'-DDE	Arochlor 1260	Arsenic
Catfish species 1 (*Ictalurus sp.*)	72	160	400	220
Catfish species 2 (*Ictalurus sp.*)	54	89	200	110
Sucker (family catostomidae)	32*	63	120	20**
Sunfish (*Lepomis sp.*)	5*	-	-	20
Pickerel (*Esox sp.*)	7*	-	-	240
	7*(d)	-(d)	-(d)	190(d)

-   -   Not detected
*   -   Below detection limit
NA   -   Not applicable or available
**   -   Less than concentration listed
(d) -   Duplicate sample result for *Esox sp*

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9483b

These results are consistent with similar studies of pesticide/ PCB's and/or metal residues within fish muscle tissue performed elsewhere (USEPA, 1976). The duplicate sample results show that the precision of the analytical results was very good.

1.3.3 Contaminant Fate and Transportation

Arsenic is mobile in the environment. Both natural and manmade arsenic can be cycled within the air, water, and soil by mechanisms such as oxidation/reduction, adsorption/desorption, precipitation/dissolution, and biological methylation and demethylation. The arsenite (+3) form of arsenic is four to 10 times more soluble in soil (and probably sediment) pore water than is the arsenate (+5) species. Arsenic can form insoluble precipitates with calcium, sulfur, iron, aluminum and barium compounds in natural waters. The partitioning of arsenic between natural waters and sediments may be controlled by both precipitation and adsorption processes. Aqueous speciation of arsenic is also controlled by biological methylation and demethylation.

Arsenic was transported to Union Lake from upstream sources by suspended particle dispersion, solute adsorption onto the sediment, and "entrapment" in adsorbed solute as heavier sediment particles were left behind. For sediments in Union Lake, the following order with respect to decreasing concentrations of fractions was found :

$As^{+5} > As^{+3} > MMAA > DMAA$.

In water, the order of predominance was found to be:

$MMAA > As^{+3} > As^{+5} > DMAA$.

The observed dominance of the arsenate (+5) species in the predominantly reduced sediments may be due to the fact that arsenic was originally adsorbed onto the sediment particulate matter under more oxidizing conditions in the upstream and it was subsequently deposited in the sediments.

The ViChem plant was shown to be the only significant source of arsenic to the Maurice River drainage basin. All river sections downstream from the site showed elevated levels of arsenic in both water and sediments. The levels of arsenic in all of the other tributaries studied were very low to undetected. Small sources below the Union Lake Dam cannot be ruled out but no evidence exists for any inputs.

Based on samples collected by ViChem at North Mill Road, an estimated 500 metric tons of arsenic has been transported past North Mill Road into the Blackwater Branch and upper Maurice River through time. Instantaneous flux measurements by a number of investigators agree with the historic trend at North Mill

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Road and indicated that the flux from the site was four to eight metric tons/yr in 1987. These fluxes were confirmed by cross checking Ebasco, USGS and ViChem data. Arsenic was transported in the basin in both dissolved and suspended forms. Arsenic concentrations varied throughout the year, inversely correlating with water flow.

Arsenic concentrations in the sediments of the Blackwater Branch and upper Maurice River positively correlated with total organic carbon content, iron content and percent clay. These data suggested that arsenic was bound to the sediments via organic carbon and ferric hydroxide matrices which coat the finer sediment fractions. Leach tests of Union Lake sediments by Winka (1985) showed that 50 to 70% of the sediment bound arsenic was not easily extractable. The fraction retained correlated positively with percent organic matter. Limited data are available within the lake to correlate arsenic in the sediments with grain size or organic matter, however, it is believed that the positive correlation that was seen in the river sediments is also applicable to lake sediments as well.

The total inventory of arsenic in the lake sediments was calculated from the NJDEP and Ebasco sediment samples. A data gap exists in that most of the sediment samples were taken from shallow areas (less than 10 feet deep) and only limited sampling was conducted in deeper portions of the lake. Nevertheless, the total quantity of arsenic bound to the lake sediments was estimated to be approximately 150 metric tons, or approximately one-third of the arsenic released off of the site through time.

The Blackwater Branch and upper Maurice River appeared to be simple conduits for arsenic released from the site based on the arsenic mass balance for 1987 and the low inventory of arsenic in the sediments. The effect of Union Lake on the present arsenic balance was unclear. Mass balance calculations showed it to be a simple conduit. However, sediment-water equilibria show that the lake water and sediments were near equilibrium. Given these conflicting mechanisms, the present fate of arsenic in the lake was not predictable. The large inventory of arsenic in the lake sediments showed that the lake has been a major sink for arsenic in the past. In view of the low river sediment loads, the lake is most likely the final depository for much of the arsenic.

Future arsenic levels in the lake are difficult to predict even if the arsenic flux from the site is eliminated since it is unclear whether inflow concentration or sediment desorption controls the lake's water arsenic concentration. Almost certainly the water arsenic concentrations would decrease if the upstream source is eliminated, but the magnitude and rate of decrease cannot be predicted until more is known about the rate of arsenic desorption from the lake sediments.

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1.3.4 Risk Assessment

A semi-quantitative risk assessment was performed using the basic methodology in the Superfund Public Health Evaluation Manual, and incorporating extensive input from the USEPA's Office of Health and Environmental Affairs (OHEA), the NJDEP, and USEPA Region II personnel.

Risks were modeled on a "worst-case" basis, using worst-case exposure assumptions and maximum contaminant concentrations, and on a "most plausible" basis, using more plausible exposure assumptions and mean contaminant concentrations. Staged adult models were prepared, integrating risks over a lifetime as opposed to simple child/adult models.

Risks were calculated for the lake at its full condition; for the lake drawdown for periods of three and five years while institutional controls limited site access; and for the lake drawndown for three years when no institutional controls limited site access. The first case, lake full, was performed to determine the risks from the lake at its full condition. The second, assuming drawdown and institutional controls, was performed to model the risks which could occur as a result of dewatering the lake for construction and limiting public access to exposed, potentially contaminated sediments. The last, drawdown with no institutional controls was performed to simulate a possible drought condition or a failure of the institutional controls to prevent public access to exposed sediments.

Exposures were calculated for recreational uses of the lake which could include swimming, boating, fishing and playing. The lake is a popular recreational area where all of these activities are known to occur during the warm season.

Arsenic was found to be the main contaminant of concern. The risk calculations from exposure to arsenic in the lake sediments, water, and fish are presented in Tables 1-5 and 1-6. The risks may be summarized as outlined below.

o Sediments

Two exposure pathways were considered, inhalation of the exposed sediments and accidental ingestion of the sediments. Ingestion was considered for sediments under very shallow water or sediments exposed at the water's edge.

Inhalation risks were very low, approximately 1 x 10^{-8} or one incident of cancer per one hundred million people exposed, via the most plausible exposure assumptions. The worst case risks were also very low, 2 to 3 x 10^{-6} or two to three incidents of cancer per one million people exposed. These calculations assumed that the lake was drawndown for three or five years as explained above.

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TABLE 1-5

SUMMARY OF CANCER RISKS FOR EXPOSURE PATHWAYS AT UNION LAKE

Pathway	Estimated Lifetime Cancer Risks	
	Most Probable	Worst-Case
Exposure Sediment Ingestion	6×10^{-6}	7×10^{-4}
Lake Water Ingestion	6×10^{-6}	4×10^{-5}
Lake Water Dermal Contact	1×10^{-7}	7×10^{-7}
Total for Recreational (non-fishing) Exposure	1×10^{-5}	7×10^{-4}
Exposure Sediment Inhalation (drawdown or drought)	1×10^{-8} 2×10^{-8}*	2×10^{-6} 3×10^{-6}*
Fish Ingestion	2×10^{-4}	2×10^{-3}

* Risks for three-year drawdown/risks for five-year drawdown.

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TABLE 1-6

ARSENIC CANCER RISKS FROM UNION LAKE
FOUR SCENARIOS OF LAKE CONDITIONS

WORST-CASE	SEDIMENT	WATER	INHALATION	TOTAL
Scenario 1 Normal Lake 70 Years	7×10^{-4}	4×10^{-5}	0	7×10^{-4}
Scenario 2 Normal Lake 67 Years Construction 3 Years	7×10^{-4} 0	4×10^{-5} 0	0 2×10^{-6}	7×10^{-4}
Scenario 3 Normal Lake 65 Years Construction 5 Years	7×10^{-4} 0	4×10^{-5} 0	0 3×10^{-6}	7×10^{-4}
Scenario 4 Normal Lake 64 Years Construction 3 Years Drought Condition 3 Years	6×10^{-4} 0 3×10^{-5}	4×10^{-5} 0 2×10^{-6}	0 2×10^{-6} 2×10^{-6}	7×10^{-4}

MOST PROBABLE CASE	SEDIMENT	WATER	INHALATION	TOTAL
Scenario 1 Normal Lake 70 Years	6×10^{-6}	6×10^{-6}	0	1×10^{-5}
Scenario 2 Normal Lake 67 Years Construction 3 Years	6×10^{-6} 0	6×10^{-6} 0	0 2×10^{-8}	1×10^{-5}
Scenario 3 Normal Lake 65 Years Construction 5 Years	6×10^{-6} 0	6×10^{-6} 0	0 3×10^{-8}	1×10^{-5}
Scenario 4 Normal Lake 64 Years Construction 3 Years Drought Condition 3 Years	5×10^{-6} 0 3×10^{-7}	5×10^{-6} 0 3×10^{-7}	0 2×10^{-8} 2×10^{-8}	1×10^{-5}

The sediment ingestion risks were higher, 6×10^{-6} for the most plausible exposure assumptions and 7×10^{-4} for the worst case assumptions. This pathway is considered valid only for sediments under very shallow water near the lake shore where activities such as playing and splashing could result in accidental sediment ingestion. In deeper water, the intimate kind of sediment contact which could result in sediment ingestion is considered unlikely.

o <u>Lake Water</u>

Lake water risks were calculated for two pathways, dermal contact during recreation and accidental ingestion during recreation. The risks were not calculated using the lake as a water source. As mentioned, the mean total arsenic concentration of the lake is above the Federal Primary Drinking Water Standard for Arsenic.

The calculated risks for lake water dermal contact were very low, 1×10^{-7} and 7×10^{-7} for the most plausible and worst-case assumptions, respectively. This is in part a result of the estimated small percentage of arsenic (6 to 12%) which is absorbed through the skin.

The accidental water ingestion risks were somewhat higher, 6×10^{-6} for the most plausible case and 4×10^{-5} for the worst case assumptions.

o <u>Fish Ingestion</u>

Fish ingestion risks are summarized in Table 1-7. This table shows that the bulk of the risk from fish ingestion is from the PCBs which were detected at low concentrations in the fish samples. The calculated risks from arsenic in the fish comprised approximately 10% of the risk from this pathway.

As pointed out in the RI, the fish ingestion risks from arsenic may be overstated. This is because it was assumed in the risk assessment that the arsenic in the fish was a combination of As (III) and As (V). Other studies suggest that the arsenic in fish is probably present in a relatively less toxic organic form which can easily pass through the body.

The PCBs found in the fish are not believed to be related to the ViChem site. The ViChem plant has no history of PCB use, production, or disposal. PCBs have a high bioconcentration factor, so small amounts in the water can produce detectable concentrations in fish. PCBs also have a high Kd, meaning that they preferentially adhere to soils and sediments rather than desorbing into the water column. While the water and sediments in Union Lake were not analyzed for PCBs, several samples were taken in the Blackwater Branch and the Maurice River upstream from the lake. PCBs were detected only sporadically and at low concentrations.

TABLE 1-7

CONTAMINANT INTAKE AND CANCER RISK ESTIMATES FOR UNION LAKE FISH INGESTION PATHWAY

CONTAMINANT	MOST PROBABLE CASE		WORST-CASE	
	CDI*	CANCER RISK	CDI*	CANCER RISK
ARSENIC	1.3×10^{-5}	2×10^{-5}	1.4×10^{-4}	2×10^{-4}
CHLORDANE	2.9×10^{-6}	4×10^{-6}	4.3×10^{-5}	6×10^{-5}
DDE	1.0×10^{-5}	3×10^{-6}	9.5×10^{-5}	3×10^{-5}
PCBs	2.3×10^{-5}	2×10^{-4}	2.4×10^{-4}	2×10^{-3}
TOTAL	-	2×10^{-4}	-	2×10^{-3}

* mg/kg-day

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1.3.5 Recommended Remedial Action Objectives

The source of the arsenic contamination in Union Lake is the groundwater discharge off the ViChem plant site. Before any remedial action in the rivers or lake downstream of the site are taken, this source should be eliminated.

The lake is now drawn down to facilitate dam reconstruction. It is expected that construction will be complete and that the lake will be refilled by June of 1990. Because of the likely timing of remedial actions at the site, with upstream actions being taken prior to downstream actions, it is unlikely that any remedial action in the lake could be taken until after the lake has been refilled. However, the NJDEP owns and operates the lake and could either postpone refilling the lake until the remediation is complete, or refill the lake after the dam reconstruction and draw it back down at the initiation of the remedial action. Therefore, the USEPA has directed that remedial alternatives for the lake be considered with the lake at its full condition and at drawdown.

Accidental ingestion of the lake water during recreational activities could pose slightly increased health risks. The total arsenic concentrations in the lake currently exceed federal standards for drinking water and New Jersey standards for fresh water bodies. However, it is not certain what controls the lake water arsenic concentration: the incoming water or desorption from the lake sediments. Because of this uncertainty, and because of the impracticality of treating the approximate 2.7 billion gallons of water in the lake discharging at a median rate of 325 cfs, remedial alternatives for the lake water are not presently being considered. The water quality at points downstream of the ViChem plant site can be monitored as the groundwater discharge off of the site is eliminated to see if this action is sufficient to improve the water arsenic concentrations.

Potential health risks were calculated from ingesting fish from Union Lake. The risks from the arsenic in the fish may have been overstated. The present level of arsenic in the fish sampled was within normal background levels for arsenic. The majority of the risks from fish ingestion were from PCBs which were detected at low levels, within acceptable USDA concentrations for fish. The source of the PCBs into the lake is not known since they were found only sporadically and at low concentrations in the sediments upstream from the lake. Because of the impracticality of remediating contamination already within fish, remedial alternatives were not considered for this pathway. The USEPA may perform additional sampling to clear up the uncertainties in this exposure pathway in the future.

The risk from inhaling exposed sediments was very low, however the risks from accidental sediment ingestion during recreational activities in shallow water were found to be somewhat elevated.

Using the mean sediment arsenic concentration and most plausible exposure assumptions, the risks were 6×10^{-6}, or a possible six incidents of cancer per one million persons exposed.

While the risk using the mean arsenic concentration is relatively low, there are "hot-spots", or areas of high arsenic concentrations in the lake. If people are exposed to sediments with high arsenic concentrations in shallow areas, the potential health risks could increase.

Table 1-8 presents calculations which show the estimated health risks which could occur at various sediment arsenic concentrations for sediments in shallow waters, which are defined as being less than approximately two and one half feet in depth. This shows that sediment arsenic concentrations of 20 mg/kg and 120 mg/kg produce risks of 2×10^{-6}, or two incidents of cancer per one-million persons exposed, and 1×10^{-5}, or one incident of cancer per one-hundred-thousand persons exposed, respectively.

Considering all of the above, the recommended remedial action objective for Union Lake is as follows:

- o Minimize public access, either through containment, removal, or institutional controls, to areas with unacceptably high sediment arsenic concentrations.

1.3.6 Additional Data Needs

Some additional data needs were presented in the RI. The need to obtain these data is dependent in some instances on the remedial actions chosen for the lake. The needs are discussed below.

- o Additional studies to determine the adsorption/desorption rates of arsenic from the sediments should be performed. These could aid in determining the fate and transport of arsenic within the sediments. Presently, it is known that arsenic can desorb from the sediments, but the extent to which this desorption will influence the water quality of Union Lake and the lower Maurice River is unknown since the partitioning mechanisms and the sorption rates are not known. Detailed information on these processes would help determine if remediation of upstream sources would lower the arsenic concentration of the lake and the lower Maurice River.

- o The mass balance of arsenic coming in and out of the la should be determined to aid in delineating whether the la water arsenic content is controlled by upstream input or desorption from the sediments. This could be accomplish

TABLE 1-8

CALCULATED RISKS FROM SEDIMENTS AT VARIOUS ARSENIC CONCENTRATIONS

Calculated Risk[1]	Sediment Arsenic Concentration (mg/kg)[2]	
	Most Probable Exposure Assumptions	Worst-Case Exposure Assumptions
1×10^{-4}	1120	190
1×10^{-5}	120	19
2×10^{-6}	20	3.8
1×10^{-6}	12	1.9
1×10^{-7}	1.2	0.19

1 Calculated risks assume sediment exposure pathways only

2 Contract Laboratory Program Contract Required Detection Limit for arsenic in soil/sediment is approximately 2 mg/kg

by measuring the flow and arsenic concentration of the lake's outflow, and comparing this with the flow and arsenic concentration at the USGS gaging station at Norma, upstream from the lake.

Logistically, the sampling program would be fairly simple to put in place. The USGS gaging station at Norma is now operational, and the frequency of sampling could be increased to monthly or semimonthly sampling for arsenic. Some type of flow measuring device could be easily installed on the dam at the controlled outlet of Union Lake. Water samples could be obtained on the same frequency as samples from the Norma station. A comparison of the results through time would provide valuable data to determine the arsenic balance of the lake. If the program were started relatively quickly, a data base would be established prior to performing any remedial action at the lake, and would help to determine its effectiveness. Also, this type of sampling would have a relatively low cost.

- As data are being gathered for the above, mathematical models should be developed to forecast the future distribution of the sediments. Present day data would be used to calibrate and optimize the model to an extent that would enable accurate predictions of sediment and surface water concentrations of arsenic above, in, and below Union Lake. Thus areas that would be most sensitive to remediation efforts could be focused upon prior to the actual cleanup. This would also aid in determining the long-term effectiveness of remediation, since it would help define possible sediment redistribution patterns.

- The areas of suspected contamination found to be sensitive to natural lake dynamics would require verification sampling prior to remediation. Verification sampling would serve as a "reality testing" mechanism to help avoid the costly remediation of a potentially uncontaminated area while better defining areas requiring remedial actions. Since the lake is a dynamic system, it is likely that any sampling conducted well in advance of a remediation would not represent the conditions to expect during remediation. Therefore, the additional sediment sampling should be conducted as close to the time of remediation as possible.

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2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

This section presents the development of the remedial action objective for the contaminated sediments and identifies and screens the most appropriate technologies to remediate the contamination.

The section describes a three-step process for identifying and screening potential technologies. First, the remedial action objective for the contaminated sediments is developed based on contaminant characterization, risk assessment and compliance with applicable or relevant and appropriate requirements (ARARs). Second, technology screening criteria are developed based on the remedial action objective, site-specific requirements and contaminant characteristics. General response actions that address the site problems and meet cleanup goals and objectives are identified. Third, potential technologies associated with each response action are identified and evaluated. The technology types are screened to determine those that are feasible or applicable to the site based upon the established criteria. The technologies that pass this screening are combined into remedial action alternatives for source control in Section 3.

In some cases, process options rather than individual technologies are evaluated to simplify the screening process. Process options are relatively similar or equivalent technologies that will achieve the same or a similar end result, or are closely related to one another. When a group of technologies is evaluated as a process option, this implies that the use of any of the technologies would be similar. This simplifies the technology screening process.

This section is comprised of three subsections:

2.2 Remedial Action Objective
2.3 General Response Actions
2.4 Identification and Screening of Technology Types and Process Options

2.2 REMEDIAL ACTION OBJECTIVE

The remedial action objective for Union Lake is to:

- Minimize public access, either through removal, containment, or institutional controls, to areas with unacceptably high sediment arsenic concentrations.

This objective was developed after considering all of the data from the RI and the risk assessment as discussed below.

2.2.1 Contaminants of Interest

As discussed in Subsection 7.1.1 of the Union Lake RI, a number of organic and inorganic contaminants were detected in Union Lake. Inorganics included arsenic, mercury and lead. Organics included Chlordane, 4,4 DDE and Arochlor 1260.

Arsenic is the main contaminant of concern. Arsenic was found in the sediments, surface water, and some fish samples. The calculated health risks from the other contaminants were found to be minimal. There was an elevated health risk calculated from ingesting fish as a result of PCBs. However, as discussed in Section 1.0, it is believed that ViChem is not the source of the PCBs, and the level of PCBs detected was very low. Therefore arsenic contamination is the focus of this FS.

2.2.2 Allowable Exposure Based on Risk Assessment

The risk assessment considered a number of different exposure pathways, and a number of different scenarios whereby the lake would be at its full condition and would be drawn down for various lengths of time. The risk assessment also considered worst-case exposure scenarios and most plausible exposure scenarios. Maximum contaminant concentrations were used to calculate risks for the worst-case exposure scenario, while mean contaminant concentrations were used to calculate risks for the most plausible exposure scenario. The end result of the risk assessment was to develop a series of calculations that showed, for both the worst-case and most plausible exposure scenarios, the total risk from recreational use of the lake, the risk from recreational exposure to various media in the lake (sediment, surface water, fish), and the risks from different types of exposure to each medium (dermal contact, ingestion, inhalation). These calculations are presented in Subsection 1.3.3 of this report.

The risks from exposure to the sediments were the focus of this FS. Potential increased health risks were calculated for incidental ingestion of lake water, and for ingesting fish from the lake. However, remedial alternatives for these two media were not included in this FS for the following reasons:

Water

- It is impractical to treat the entire water volume within the lake, estimated to be approximately 2.7 billion gallons, when the lake is at its full condition.

- There is a constant influx of arsenic into the lake water via arsenic in the water of the upper Maurice River entering the lake. The mean flow rate of the river entering the lake is at least 123 CFS, which is

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the mean flow of the Maurice River at the Norma gaging station approximately four miles upstream from the lake. It is impractical to treat this flowing stream as well.

Fish

- There are no practical remedial alternatives to reduce arsenic concentrations already found in fish.

- The risk assessment assumed that the arsenic detected in the fish was a combination of As (III) and As (V) in the same proportion as was found in the studies used to determine the Cancer Potency Factor (CPF) for arsenic. In fact, other studies suggest that the arsenic found in the fish would be an organic form that is relatively nontoxic. The form of arsenic found in the fish samples was not determined, but may be determined in further studies by the USEPA.

- The concentration of arsenic in the fish samples, approximately 1 mg/kg, is within normal background levels for fish and shellfish in the US.

Allowable concentrations of arsenic in the sediments, considering human recreational exposure, were calculated from the risk assessment. The most plausible exposure pathway models were used to calculate the health risks that would be produced at various arsenic concentrations. Then a target risk level was established, and the sediment arsenic concentration corresponding to the target risk level became the basis for the sediment remedial alternatives.

Two sediment exposure pathways were considered: inhalation while the lake was drawn down, and accidental ingestion. The most plausible risks calculated for each of these pathways are summarized below:

- Inhalation - This pathway is valid only when the lake is drawn down. Lake drawdown durations of three and five years were considered. The most plausible risk from this pathway is approximately $1x10^{-8}$, or one incident of cancer per one hundred million exposed persons. Because these potential risks were so low, no remedial alternatives were considered for this pathway.

- Ingestion - This pathway comprises the majority of the risk from the sediment exposure pathways. Using the mean arsenic concentration in the sediments, the present most plausible risk calculates to $6x10^{-6}$. However, there are hot spots, or areas of high contamination, in the lake at certain locations. Using the most plausible pathway models, a sediment arsenic

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concentration of 120 mg/kg corresponds to a risk of $1x10^{-5}$, or one incident of cancer per one hundred thousand people exposed to the sediments.

After reviewing these data, the USEPA, in conference with the NJDEP, determined that the submerged sediment cleanup level should be 120 mg/kg. However, in order to provide an extra measure of protection of human health, a cleanup level of 20 mg/kg was established for the sediments in the more accessible areas of the lake, including the public beach, the tennis and sailing club, and the residential shoreline. An action level of 20 mg/kg in the more accessible areas corresponds to a risk of $2x10^{-6}$, or two incidents of cancer per one million people exposed to the sediments. These are the sediment cleanup levels that the USEPA directed be used for this FS.

To determine the remedial strategy for the lake, both the location of the sediments, as well as their arsenic concentration, were considered. Two factors were considered for determining the location of sediments for remediation: depth under water and areal distribution. These factors are discussed below.

The depth of water over the sediments influences the likelihood of sediment exposure. The sediment ingestion pathway model assumes that individuals could be exposed to sediments in such an intimate fashion that they may accidentally ingest sediment. This requires that the individuals must be in shallow water where vigorous activities such as splashing and playing could allow for accidental sediment ingestion. The USEPA Region II, in conference with the USEPA Office of Health and Environmental Affairs (OHEA), determined that this type of contact could only reasonably occur when the sediments were under shallow water, approximately two and one-half-feet or less. As a result, the base case criterion for remediation is that all sediments that underlie a water column depth of less than two and one-half-feet, and exceed the action level for that particular area of the lake (120 mg/kg for the less accessible areas and 20 mg/kg for the more accessible areas), would be remediated.

The location of the sediments also influences the remediation strategy. For example, some areas of the lake are frequently utilized by the public. These areas include the public beach and the tennis and sailing club. Other areas are not as highly frequented by the public, but are highly accessible, such as the residential eastern shoreline. The remainder of the lake is not frequented by the public for swimming and wading, and is also less accessible.

Considering all of the above, the USEPA, in concurrence with the NJDEP, determined that the sediment remediation would be conducted as follows:

- In the most accessible areas of the lake (the public beach and the tennis and sailing club) all sediments with an arsenic concentration of 20 mg/kg or greater underlying a water depth of five feet would be remediated. This provides an extra measure of human health protection in these two highly utilized areas. This area is shown in Figure 3-2.

- In the residential areas of the lake along the eastern shoreline, all sediments with an arsenic concentration of 20 mg/kg or greater underlying a minimum water depth of 2.5' continuing up to a five foot water depth within 150 feet of the shoreline would be remediated. This portion of the remediation is shown in Figure 3-2.

- For the remaining areas of the lake, where activities that promote sediment ingestion are less likely to be engaged in, the action level would be 120 mg/kg. All sediment with an arsenic concentration of 120 mg/kg or greater underlying a minimum water depth of 2.5 feet, continuing up to a five foot water depth within 150 feet of the shoreline would be remediated. This final area of remediation is also shown in Figure 3-2.

Conducting the remediation to variable action levels and different water depths takes into account the usage patterns in the lake. The most stringent action level, 20 mg/kg, and remediation to a lake depth of five feet, would be implemented in the most utilized and publicly accessible area. The action level and lake depth of remediation chosen for the remainder of the lake combine to take into account the less likely potential for repeated sediment exposure in these areas.

2.2.3 Allowable Exposure Based on ARARs

Lake Water

The following ARARs establish a 50 ug/l total arsenic concentration as the criteria/standards for drinking water, groundwater or surface water quality:

- Safe Drinking Water Act MCLs;

- New Jersey Water Standards (NJAC 7:9-6.6) Groundwater Quality Criteria;

- New Jersey Water Standards (NJAC 7:9-4.14C) Surface Water Quality Criteria for FW2 Waters; and

- New Jersey PDES (NJAC 7:14A-6.15) Maximum Concentration of Constituents for Groundwater Protection.

In addition, the Clean Water Act Water Quality Criteria for Protection of Human Health established a 2.2 ng/l arsenic level for water and fish ingestion, which was later adjusted to 25 ng/l for water ingestion only.

As shown in Table 1-3, although the current upper lake water and lower lake water contain total arsenic exceeding ARAR criteria/standards, the dissolved arsenic concentrations of the lake water are very close to the 0.05 mg/l limit.

Lake Sediments

No federal or state ARARs exist that establish a cleanup action level for contaminated soils and sediments. The NJDEP, which has a department guidance value for arsenic in soils, and the federal government, through the RCRA program, have established certain criteria by which a soil or sediment may be considered hazardous or nonhazardous.

The NJDEP's department guidance value for arsenic in soils is 20 mg/kg. However, the NJDEP stresses that this is a guidance value only.

The RCRA program has established certain criteria by which a soil or sediment may be considered hazardous or nonhazardous. In the case of soils or sediments contaminated with arsenic, if the leachable arsenic concentration following a RCRA Part 261 Extraction Procedure (EP) Toxicity Test or Part 268 Toxicity Characteristic Leaching Procedure (TCLP) test exceeds 5 mg/l, the soil or sediment may be considered hazardous because it is "characteristic". Also, if a soil or sediment has been contaminated with arsenic as a result of contact with a listed hazardous waste, the soil or sediment is also considered a listed hazardous waste. In the case of the Union Lake sediments, the elevated arsenic concentrations are a result of the sediments being contacted by water containing arsenic derived from the listed hazardous waste number K 031. As a result of this, personnel from the USEPA's Site Policy and Guidance Branch, Hazardous Site Control Division (HSCD), have determined that the contaminated sediments shall be considered a listed hazardous waste for the purposes of disposal. This designation does not, however, establish a cleanup level based on the arsenic concentration.

In summary, no state or federal ARARs exist to establish a cleanup level for the arsenic contaminated sediments in Union Lake. The cleanup levels and the areas requiring remediation were established as discussed above under risk-based cleanup levels.

2.2.4 Development of the Remedial Action Objective

If the human health risks, as well as the elevated concentrations of arsenic found in the sediments of Union Lake, are to be reduced to acceptable levels, remedial action must be developed to address the following objective:

- Minimize public exposure to sediments with unacceptably high arsenic concentrations, either through removal, containment, or institutional controls.

The following discussions summarize the findings and criteria that form the basis for the remedial action objective.

Elevated arsenic concentrations were found in the lake's water and fish. As discussed above, it is impractical to treat the lake water because of the size of the lake, the magnitude of flow containing arsenic coming into the lake, and the necessity of eliminating the source of arsenic into the basin before remediating downstream contamination. Therefore remedial alternatives for the lake water were not considered. No remedial alternatives were considered for the fish in the lake because the detected arsenic concentrations were within USDA dietary guidelines and the form of arsenic in the fish may actually be relatively nontoxic.

Elevated arsenic concentrations were also found in the lake sediments. No federal or state ARARs exist which establish a cleanup level for contaminated sediments. The risk assessments determined that accidental ingestion of sediments containing greater than 120 mg/kg arsenic in very shallow waters during recreational activities would produce an increased cancer risk of $1x10^{-5}$, or one incident of cancer per one hundred thousand exposed persons. Exposure to exposed sediments through inhalation posed an acceptably low risk.

The focus of this FS was to determine remedial alternatives for sediments containing greater than 20 mg/kg arsenic in the more accessible areas and 120 mg/kg in the less accessible areas. The areas requiring remediation are discussed in Subsection 2.2.2.

2.3 GENERAL RESPONSE ACTIONS

2.3.1 Criteria for Initial Screening of General Response Technologies

The number of general response actions and associated remedial technologies that were potentially applicable to Union Lake was quite extensive. The technologies on this list were screened based upon their ability to address the remedial response objective. The screening process was based upon a set of

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criteria relevant to the protection of public health and the environment, as well as to site-specific conditions and the contaminants.

Guidance was utilized from the National Oil and Hazardous Substances Contingency Plan as revised November 20, 1985; USEPA Guidance on Feasibility Studies under CERCLA, USEPA Interim Guidance or Superfund Selection of Remedy (December 1986); USEPA Interim Guidance for FY87 ROD's (July 1987); and USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (March 1988). In addition, the screening process incorporated the professional judgement of engineers performing the Feasibility Study.

2.3.2 Identification of General Response Actions

Based on the established remedial action objective, site conditions, and waste characteristics, a preliminary screening of potential general response actions was conducted. A list of general response actions typically considered for the cleanup of hazardous waste sites is presented in Table 2-1. The general response actions listed in Table 2-2 were determined to be feasible for the site and would address the remedial objective. General response actions such as pumping and collecting contaminated groundwater, storing hazardous materials, providing an alternate water supply for the community, and relocating residents were judged as not applicable for this site.

The no action category involves activities that restrict public access (e.g., fencing) to contaminated areas and that monitor contaminant migration (e.g., monitoring wells). Continued monitoring of a contaminated medium over time will enable the determination of natural restoration rates occurring through natural attenuation and biodegradation.

Containment actions include technologies that involve little or no treatment, but provide protection to human health and the environment by reducing the mobility of contaminants and risks to exposure. Examples of containment actions are covering waste deposits and controlling groundwater movement by using low permeability barriers or containment walls.

Treatment actions include solids treatment and associated waste-water treatment technologies that act to reduce the volume, mobility, and/or toxicity of contaminants. There are many sediment treatment technologies that are effective for metals, including thermal vaporization/oxidation, extraction and fixation. Wastewater treatment technologies include physical, chemical and biological treatment.

TABLE 2-1

POTENTIAL GENERAL RESPONSE ACTIONS

1. No Action
2. Containment
3. Treatment and Disposal
   - Complete Removal (Contaminated Sediment)
   - Partial Removal (Contaminated Sediment)
   - Pumping (Wastewater)
   - On-Site Treatment (Sediment and Wastewater)
   - Off-Site Treatment (Sediment and Wastewater)
   - In Situ Treatment (Sediment)
   - On-Site Disposal (Sediment and Wastewater)
   - Off-Site Disposal (Sediment and Wastewater)

TABLE 2-2

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

SARA Remedial Categories	General Response Actions	Remedial Technologies
1. No Action	Monitoring	- Monitor and analyze sediment, fish and lake water
	Migration Assessment	- Sediment Transport Modeling
	Restricted Access/ Use	- Fence access areas - Prohibit fishing, crabbing, swimming and water sports - Prohibit irrigation
	Public Awareness	- Post warning signs - Inform local officials and residents - Hold public meetings
2. Containment	Capping	- Clay cap - Synthetic membranes - Chemical sealants
	Covering	- Filter fabric - Coarse sand - Stone/gravel
	Barriers	- Silt curtains - Dikes/piers - Sheet piling
3. Treatment and Disposal		
a. Sediment	Complete or Partial Removal	- Excavation (backhoe, bulldozer, front-end loader, dragline, low ground pressure backhoe) - Mechanical dredging (clam shell, bucket loader, dipper, Souerman dredge, terra marine scoop)

TABLE 2-2 (Cont'd)

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

SARA Remedial Categories	General Response Actions	Remedial Technologies
3. Treatment and Disposal a. Sediment (Cont'd)	Complete or Partial Removal	- Hydraulic dredging (suction/dustpan, cutterhead, hopper dredge, horizontal auger-cutter dredge) - Pneumatic dredging (Airlift, Nametech, Oozer, Pneuma)
	On-Site or Off-Site Treatment	- Incineration - Wet oxidation - Acidification/alkalization - Chemical extraction - Chemical fixation - Hydroclones - Drying beds - Gravity thickeners - Sedimentation basins/lagoons - Dehydro drying beds - Ultrasonic dewatering - Centrifuge - Filter press - Vacuum filter - Belt filter press
	In Situ Treatment	- Extraction - Grout Injection - Vitrification
	On-Site or Off-Site Disposal	- Construct On-Site RCRA Landfill - Construct Off-Site RCRA Landfill - Existing Off-Site RCRA Landfill - Construct On-Site Nonhazardous Landfill - Construct Off-Site Nonhazardous Landfill - Existing Off-Site Nonhazardous Landfill

TABLE 2-2 (Cont'd)

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

SARA Remedial Categories	General Response Actions	Remedial Technologies
3. Treatment and Disposal (Cont'd)		- Ocean Disposal - Lake Deposition - Plant Site Deposition - Construction Aggregate
b. Wastewater	On-Site Treatment	- Coagulation flocculation/precipitation - Biodegradation - Oxidation - Neutralization/pH adjustment - Clarification - Filtration - Ion Exchange - Adsorption - Reverse osmosis
	Off-Site Treatment	- POTW and Industrial Wastewater Treatment Plant
4. Transportation Technologies		- Truck - Pipeline

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

2.4.1 Identification, Screening and Evaluation of Technologies

The next step in the FS process consists of identifying the categories of remedial technologies associated with each response action that are applicable to the Union Lake site and determining the feasibility of achieving the remedial objective by using those technologies.

The remedial technology categories that are selected for initial screening were presented in Table 2-2.

The screening of remedial technologies is based on the remedial action objective, site-specific conditions, waste characterization and the extent of contamination. Waste characteristics include physical properties such as volatility, solubility and density; specific chemical constituents such as total organic carbon and metals; and properties that affect the performance of a technology. Site characteristics gathered during the RI are reviewed to identify conditions that may limit or favor the use of certain remedial technologies. Technologies whose use is clearly precluded by waste or site characteristics are eliminated from further consideration.

Several sources are used during the initial screening of technologies, including the following:

- Remedial Action At Waste Disposal Site Handbook, USEPA, June 1982.
- Handbook For Evaluating Remedial Action Technology Plans, USEPA, August 1983.
- Review Of In-Place Treatment Techniques For Contaminated Surface Soils, Volume 1: Technical Evaluation, USEPA, September 1984.
- Technologies Applicable To Hazardous Waste, USEPA, May 1985.
- RCRA/CERCLA Alternative Treatment Technology Seminar, USEPA, May 1986.
- Handbook For Stabilization/Solidification Of Hazardous Wastes, USEPA, June 1986.
- Mobile Treatment Technologies For Superfund Wastes, USEPA, September 1986.

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In addition to these references, the annual proceedings of hazardous waste research symposia/conferences were used as sources of information (e.g., "Proceedings of Annual Research Symposia" published by USEPA; and the "Conference on the Management of Hazardous Materials Control Research Institute").

2.4.1.1 No Action

Description: No action is not a category of technologies but a group of activities that can be used to address the contamination problem when no remediation measures would be implemented. These activities mentioned below will be used to construct a no action alternative later in this report as required by the Superfund Amendments and Reauthorization Act (SARA) and the National Contingency Plan (NCP).

- Increase public awareness through public meetings, presentations in local schools, press releases, and posting additional signs;
- Restrict access to the lake for recreational activities;
- Prohibit the utilization of lake water for irrigation purposes; and
- Model sediment distribution patterns and monitor sediment, lake water and fish to assess contaminant migration periodically.

Initial Screening: The no action approach is included through the detailed evaluation of alternatives as a baseline for comparison with other remedial alternatives.

2.4.1.2 Containment

The primary route of exposure to the sediment-bound arsenic in Union Lake is ingestion of the sediments. Isolation of the contaminated sediments from the surrounding environment would eliminate this route of exposure. The containment technologies evaluated below either provide some degree of isolation or are functionally associated. Containment of contaminated sediments would consist of capping, covering and barriers.

Capping

Capping technologies isolate the sediments by installing a cover that contains the sediments in place and, with varying levels of effectiveness, eliminates direct contact, particulate suspension and dust generation. Capping of contaminated sediments could be achieved by utilizing any one or a combination of the following; a clay cap, synthetic membranes and chemical sealants. The cap is normally intended to be temporary, but could be permanent where extensive subsurface contamination precludes excavation and the removal of wastes because of the potential hazards and/or unrealistic costs.

- Clay Cap

  Description: Clay layers are commonly used as cover for landfills that contain both hazardous and nonhazardous wastes. Bentonite, a natural clay with high swelling properties, is often transported to a site and mixed with on-site soil and water to produce a low permeability layer. An impermeable clay cap would not only physically isolate the contaminated sediments, but also prevent interaction between the sediments and the overlying water. An impermeable clay cap would also minimize the leaching of contaminants to lake water by creating an impermeable barrier.

  Initial Screening: The installation of a clay cap on the sediments under lake water would require extensive dewatering and construction of a stable subbase, which are almost infeasible techniques. Clay caps are susceptible to cracking, settling and ponding of liquids, particularly when oversaturated with water, resulting in loss of impermeability and fine material suspension. A clay barrier would also bring about adverse impacts to underlying benthic life. Because of low implementability and low reliability, the technology of clay capping for sediment containment is eliminated from further evaluation. However, clay capping is feasible and effective for landfill construction.

- Synthetic Membranes

  Description: Flexible synthetic membranes are made of polyvinyl chloride (PVC), chlorinated polyethylene (CPE), ethylene propylene rubber, butyl rubber, Hypalon and neoprene (synthetic rubbers), or elasticized polyolefin (USEPA, 1985b). Recent applications have seen the use of synthetic materials as both liners and caps in landfills and other waste facilities. Thin sheets are available in sections of variable width. The sheets are overlapped and spliced in the field. Special adhesives and sealants are used to ensure linear integrity.

  Initial Screening: The installation of a synthetic membrane on the sediments under lake water would also require extensive dewatering and construction of a stable subbase that has the same infeasibility as installation of a clay cap. The integrity of synthetic liners can be damaged by uneven settling. Synthetic liners under water would require an overlaying anchor layer to minimize damage and to prevent the liner from floating. Synthetic liners are labor-intensive, since sealing requires special field installation methods, particularly for submerged installation. As with the clay barrier, synthetic liners would also adversely impact the benthic community. Due to the low implementability and low reliability, this technology is eliminated from sediment capping. However, synthetic membranes will be retained for evaluation as part of a multimedia cap for landfill facilities.

- Chemical Sealants

  Description: Chemical stabilizers and cements can be added to relatively small amounts of soils to create stronger and less permeable surface sealants. Portland cement or bitumen (emulsified asphalt or tar) is suitable for mixing with sandy soils to stabilize and waterproof them. Other soil additives include chemical dispersants and swell reducers. Soluble salts such as sodium chloride, tetrasodium pyrophosphate, and sodium polyphosphate are added primarily to fine-grained soils with clay to deflocculate the soils, increase their density, reduce permeability, and facilitate compaction.

  Initial Screening: Extensive dewatering, mixing, spreading and compaction are required to achieve a low permeability cap. Strict moisture control and a stable subbase for chemical sealant formation are unlikely to be provided by silty sediments. Some of these sealant-sediment mixtures would not prevent biota from growing or burrowing through to the sediment underneath the seal. This technology is still in a developmental stage and very little information is available on the implementability of chemical sealants in a water environment, such as the effects on water quality and resistance to water forces. Based on the unique site conditions, difficulty in implementation and low reliability, this technology is eliminated from further consideration.

Covering

- Filter Fabric

  Description: Filter fabric is a woven material that comes in various pore sizes. It can be designed to allow water and gases formed by biological activity to escape while preventing the passage of most particulates. Therefore the use of filter fabric is considered to eliminate the redistribution of bottom sediments. It has a limited life expectancy, but is commonly used in landfill caps and has had some applications in water environments.

Initial Screening: Some type of anchor or heavy material (e.g., sand, gravel) must be placed over the filter fabric to keep it in place on top of the sediments. In addition, filter fabric cannot prevent the growing or burrowing of biota into the contaminated sediment. For these reasons, it is removed from further consideration as an individual technology. Instead, it was combined with other complementary technologies, such as sand covering, for further evaluation.

- Coarse Sand

Description: Covering contaminated sediments with a layer of coarse sand is an established practice to provide a positive effect in reducing public health risks from direct contact and possible ingestion of contaminants. The sand blanket would also reduce the environmental impact by minimizing the potential for bioaccumulation and erosion under normal weather conditions. The high density coarse sand would, to some extent, resist severe erosion during a storm event.

Initial Screening: The effectiveness of contaminant covering would be proportional to the thickness of the sand layer installed. This technology is a proven and demonstrated simple technique. It may not provide a totally reliable barrier to biota growing or arsenic leaching. Placement of the sand layer may cause resuspension and redistribution of sediments. However, a coarse sand layer would provide a quick and economical means of lake restoration for recreational use. Therefore this technology is retained for further evaluation.

- Stone/Gravel

Description: A layer of crushed stone and/or gravel could be placed directly over the sediment. The water forces that resuspend and carry the contaminated sediments would act on this rough surface of larger particles, which have a greater resistance to movement than the finer sediments underneath. This is a common engineering practice that is used to control erosion of materials in a water environment.

Initial Screening: Two major disadvantages of this material are that placement would cause major resuspension and redistribution of sediments, especially if placed in standing water, and that a significant portion of the material would immediately sink down into the soft sediment and be rendered ineffective. Furthermore, over a period of time, more of the stone/ gravel layer may sink down into the soft sediments and more contaminated material would work up toward the surface. Placement of a layer of stone/gravel alone would still allow the transport of, and eventually contact with, some contaminated sediment. Therefore the technology is eliminated from further evaluation.

Barriers (Sediment Dispersion Control)

The following technologies provide for temporary or permanent barriers to isolate the contaminated sediments in order to minimize agitation and resuspension.

- Silt Curtains

  Description: Silt curtains constructed from filter fabric are used to reduce the transport of contaminated sediments. Suspended from floats or staked into the bottom sediments, the curtain is extended around the work area. The performance of this technique is sensitive to surface water disturbances, which may tear or overtop the fabric. The technology is well developed for erosion control on land, but has not been thoroughly tested in projects where highly contaminated sediments are suspended in water, especially in the case where the contaminant is associated with very fine silt particles. However, the filtration effectiveness of this technology can be increased by using two curtains in parallel to provide a buffer zone between them to further control the suspended particles and turbidity.

  Initial Screening: Silt curtains could be effective in minimizing resuspended particle migration during the sediment removal activities. Optimum use of silt curtains would be based on the results of surface water modeling and dye studies, which would enable proper selection of locations for the barriers. This technology is retained for further evaluation.

- Dikes/Piers

  Description: Earth and rockfill structures can be used to cordon off the areas to be cleaned and isolate them from uncontaminated areas, thus creating a safe area for

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public use. Piers can provide an effective barrier to direct the suspended sediment away from uncontaminated areas. Enclosing an area within an enclosed dike will allow surface water to be pumped from this area, providing a semi-dry condition for excavation.

Initial Screening: Piers/dikes cannot provide total isolation from the spread of contaminated sediment except within an enclosure pier. The construction of a diked area would have an adverse environmental impact on the lake ecosystem. This technology could provide a safe area for swimming, but would minimize other water sport uses such as boating. Since the configuration of sediment transport in the lake is unknown, its reliability would be considered low. For these reasons, dikes/piers are eliminated from further consideration as an individual technology.

- Sheet Piling

  Description: Sheet piling driven into the sediments can be used as a barrier to limit the spread of contaminants outside the work area. An enclosure constructed of interlocking sheet piles could substantially reduce the movement of contaminated water and suspended sediments to areas outside the piling. This technique could also be extended such that water within the enclosure is pumped out and work could proceed within a semi-dry state. The use of sheet piling is a commonly applied technology.

  Initial Screening: In situ dewatering would not be required for contaminated sediment removal since the dewatering of dredged sediments would be more cost effective. This technology is therefore eliminated from further consideration.

2.4.1.3 Treatment and Disposal

Complete or Partial Removal

As discussed in Section 3, the risk assessment identified sediments with an arsenic concentration greater than 20 mg/kg in the more accessible areas and 120 mg/kg in the less accessible areas to be an immediate public health risk. The areas to be removed are presented in Figure 3-2. The total volume of sediment in Union Lake to be removed is approximately 131,000 cubic yards. Excavation concerns for the sediments when the lake is at its full condition would be different than concerns for the sediments when the lake is drawn down. Dredging techniques would be applicable for sediment removal when the lake is at its full condition, while primarily dry excavation techniques, possibly coupled with dredging technologies, would be appropriate for drawdown conditions. Treatment and disposal technologies are applicable to the sediments in both cases.

- <u>Excavation</u>

  <u>Description</u>: This category of removal technologies refers to construction equipment that is typically used on land to excavate and handle solid materials. The equipment includes backhoes, bulldozers, front-end loaders and draglines. Large backhoes have production rates up to about 150 cubic yards per hour (cy/hr). Smaller models with low ground pressures are capable of working on soft soils.

  Bulldozers and front-end loaders have average excavation rates between 50 and 100 cy/hr and 70 and 180 cy/hr, respectively. They cannot load sediment that is not close to the shoreline. Draglines are suitable for excavating large land areas to depths ranging from 12 to 30 feet deep with boom lengths ranging from 30 to 200 feet.

  <u>Initial Screening</u>: The types of equipment discussed above, including bulldozers and front-end loaders, would be suitable if the remediation is conducted at the lake drawdown condition. Even at drawdown the northern end of the lake may exhibit marshy conditions necessitating the use of a low ground pressure backhoe. Draglines would require the installation of an extensive network of access roads to reach all sections of the lake. In addition, they would require the use of drag buckets resulting in deep excavations when they are dropped from the boom. Such deep excavations are not required when only the top one foot of sediment must be removed.

  Based on the above considerations, bulldozers, front-end loaders and low ground pressure backhoes might be used as a primary means of removing the contaminated sediments if remediation were conducted when the lake is drawn down. In addition, one or more of these types of equipment would be used for other construction support activities. Excavation is feasible and is retained for further evaluation.

- <u>Mechanical Dredging</u>

  <u>Description</u>: Mechanical dredging refers to the use of excavation equipment such as clamshells and bucket loaders that are usually mounted on barges. The main advantage of mechanical dredging is the removal of sediments at nearly in situ densities by not adding any

water, therefore maximizing the solids content and minimizing the scale of facilities required for dredged material transport, treatment and disposal. On the other hand, because mechanical dredging removes bottom sediment through the direct application of mechanical force to dislodge the material, sediment resuspension and turbidity are often high. In addition, this method of sediment removal has a characteristically low production rate (USEPA, 1985c).

Initial Screening: Most of the barge-mounted dredges require from five to six feet of draft. The portions of the lake to be remediated include areas under 5 feet of water or less. These access restrictions, combined with the high resuspension of sediments associated with mechanical dredging, provide adequate reasons for eliminating the mechanical dredging category of removal technologies from further consideration.

o Hydraulic Dredging

Description: Hydraulic dredging utilizes water as the medium for transporting sediments from their in-place location to a discharge point. Slurries of 10 to 20 percent solids by weight are common in standard hydraulic dredging operations. The operations are usually barge-mounted and have high production rates. The four different types of hydraulic dredges commercially available are suction/dustpan, cutterhead, hopper dredge and horizontal auger-cutter dredge.

The plain suction dredge relies solely on suction to dislodge, capture and transport the excavated slurry. The dustpan dredge is a modified suction dredge. It features a wide flared dredging head and utilizes high-pressure water jets to loosen and agitate sediment, then captures them in the dustpan. Both types are effective in the removal of relatively free-flowing sediments.

A cutterhead suction dredge utilizes circular cutter blades, which rotate at the bottom of a suction pipe. This dredge is suitable for dredging both fine (silt and clay) and coarse (gravel and loose rock) materials.

The hopper dredge is basically a self-contained ship that uses suction to draw sediments into hopper compartments within it. After all hoppers are full, the dredge is moved to a transfer location where the materials are pumped out. This dredge requires extensive maneuvering space and is used for ocean operations.

The horizontal auger-cutter dredge utilizes a hydraulically operated boom to raise and lower an auger-cutter/suction assembly to the sediments. The sediments initially loosened by the auger-cutter assembly are then transported by suction as a slurry through a floating pipeline or transfer barge to the treatment/ disposal location. Smaller versions of this dredge can remove a maximum depth of sediment of approximately one and a half feet with each pass, and can be transported to relatively isolated (in terms of navigation) water bodies such as inland rivers. A series of tests is presently being performed on the most commonly used portable dredge, the Mud Cat*. Preliminary results indicate that sediment resuspension is negligible. Reduced resuspension would have to be obtained by sacrificing optimization of the dredging operation. This would be accomplished by increasing the amount of water taken in by the dredge during operation.

<u>Initial Screening</u>: The suction/dustpan dredges are usually large vessels geared for the maintenance dredging of major waterways. Due to their size and draft they would not be accessible to Union Lake. In addition, underwater plants and debris could block the suction lines. Therefore, the suction/dustpan dredges are considered unimplementable and are eliminated from further evaluation.

Cutterhead dredges are usually designed for large production projects and are mounted on large barges. Due to their size and five to six foot draft requirements, they would not be accessible to the site area and are eliminated from further evaluation.

The hopper dredge requires extensive maneuvering to operate. Under anticipated site conditions and nominal water depths, this system is not considered appropriate for Union Lake. It is therefore eliminated from further consideration.

Portable horizontal auger-cutter dredges are in wide use, particularly in shallow waters such as small reservoirs, streams and lagoons. They also characteristically have low depths of vessel draft (many less than two feet) allowing them to be used in a shallow-water application. Because of the accessibility to tl site and low sediment resuspension, this type c hydraulic dredge is retained for further evaluation.

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* In this report any mention of trade names of commercial products and processes does not constitute endorsement or recommendation for use.

o **Pneumatic Dredging**

Description: Pneumatic dredges use compressed air and hydrostatic pressure to draw sediments to the collection head and through the transport piping. Four types of pneumatic dredges, including Airlift*, Nametech*, Oozer* and Pneuma* are commercially available. Pneumatic dredges can yield denser slurries than conventional hydraulic dredges with lower levels of turbidity and resuspension of solids, but they are capable of only modest production rates. These dredges can be relatively easily dismantled and transported by truck, but have limited availability in the United States.

Initial Screening: Some pneumatic dredges may not be suitable for shallow deposits because they require a minimum depth to build up enough air pressure for operation. The minimum depth required would be greater than what is available in Union Lake. Some of these dredges are being evaluated by the USEPA for removing contaminated sediments; however, operational data are limited (USEPA, 1985c). Because of the limited availability, minimum depth requirements, and lack of operational data, this category of dredges is eliminated from further evaluation.

On-Site or Off-Site Treatment Technologies

Although the same remedial technologies are applicable for on-site or off-site treatment of sediments removed from Union Lake, on-site treatment should be considered first to minimize transportation and handling costs. Even when on-site treatment is not completely possible, steps should be taken on-site to reduce the sediment water content and volume in order to minimize transportation costs. The applicability of complete or partial on-site treatment will depend primarily on the availability of land upon which to construct facilities. It appears that sufficient land is available at the inland area of Union Lake for sediment handling and treatment. Table 2-2 presented a list of the on-site and off-site treatment technologies that were screened relative to their potential applicability and feasibility for the cleanup of contaminated sediments.

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* In this report, any mention of trade names of commercial products and processes does not constitute endorsement or recommendation for use.

Thermal Treatment - Sediment

This technology category includes the use of incineration units and wet oxidation units to treat the arsenic-contaminated sediments.

Arsenic compounds can be vaporized in the range of 100°C to 450°C and can be oxidized to form an As_2O_3 emission (Dean, 1985). The vapor-phase arsenic emission should be treated in an air pollution control device such as a water scrubbing system.

- Incineration

  Description: Incineration involves the thermal oxidation or destruction of organic matter. Incineration units such as multiple hearth, rotary kiln or infrared systems would evaporate water from the sediment slurry and decompose any organic matter. Therefore they could be used for sediment drying and volume reduction. Incineration would only vaporize arsenic from the sediments into the scrubbed water. Subsequent and suitable treatment would be required to remove arsenic from the scrubbed water prior to discharge to the lake. There is currently no established incineration technology that will destroy arsenic; only vaporize, sublime or melt the arsenic. Both portable and stationary equipment are available for both on-site and off-site incineration. To be useful in either case, the processing capacity of the incinerator should be consistent with the rate of sediment generated by the dredging operation.

  Initial Screening: The vaporization of arsenic would not require the high temperatures generated by an incinerator. Incineration requires very high capital cost, and operating and maintenance costs. In addition, the costs of removing arsenic from the scrubbed water are estimated to be very high. Incineration may melt a certain amount of arsenic to ash, resulting in a problem with regard to the disposal of the potentially hazardous ash. For these reasons, incineration is considered ineffective, and is eliminated from further evaluation.

- Wet Oxidation

  Description: Wet air oxidation or wet supercritical water oxidation uses elevated temperature (500°F to 600°F) and pressure (100 to 500 atm) to oxidize contaminants. This process was developed mainly for treating pumpable aqueous and sludge wastes, which are too dilute (less than 15% organics) to treat economically by incineration. There is currently no established wet oxidation technology that would destroy arsenic. This technology would only vaporize and oxidize arsenic.

Initial Screening: The wet oxidation products containing arsenic oxides would remain dissolved and suspended in the liquid. The off-gas would contain dissolved arsenic oxides and hydrocarbons from the organic matter in the sediments. It would be very difficult to separate the arsenic-contaminated suspended solids and the inert fine silt. This technology category has not been demonstrated feasible for arsenic removal in a pilot-scale test or a full-scale operation. Therefore wet oxidation technologies are eliminated from further evaluation.

Chemical Treatment - Sediment

Chemical treatment can be used to remove arsenic from both the dredged sediment and the associated liquid wastes. Sediments can be treated chemically using acidification/alkalization, extraction and fixation.

- Acidification/Alkalization

  Description: Acidification and alkalization consist of the addition of an acid or an alkali to the sediments to solubilize and leach arsenic into solution so that the arsenic can be removed from the sediments. Hydrochloric acid and sodium hydroxide are the most commonly used acid and alkali for this type of treatment.

  Initial Screening: Both acidification and alkalization were tested in the bench-scale treatability studies (Section 6.0 of the RI report) to determine the feasibility of this technology to leach arsenic from the sediments. The test results demonstrated a low efficiency for leaching at a low pH value (i.e., 3.0), but a high efficiency of leaching at an extremely high pH value (i.e., 12.0). The alkali-treated sediments contained 14 mg/kg of total arsenic, which is below the treatment criterion of 20 mg/kg. However, alkalization resulted in an unstable process and generated a large amount of fine silt, which was very difficult to settle out. Extraction utilizing water and sodium citrate demonstrated better results. Therefore both acidification and alkalization were eliminated from further evaluation.

- Extraction

  Description: This technology would involve the extraction of the arsenic from the dredged sediments using water, a solvent, a wetting agent or any combination of the three. The supernatant solvent (extractant) containing the arsenic would then be further treated for arsenic removal prior to discharge to the lake. The sediment, after being washed with water for solvent recovery, would be disposed of as a nonhazardous waste.

Initial Screening: Extraction was evaluated in the bench-scale treatability studies (Section 6.0 of RI Report) to determine the feasibility of this technology to extract arsenic from the sediments. The tests involved using extracting media such as water, sodium citrate, sodium oxalate and ethylenediaminetetraacetate (EDTA), all commonly used extracting agents.

The treatability test result showed that the resultant coarse sand after a water wash contained 36 mg/kg arsenic, compared with an initial sediment (sand plus fine silt) concentration of 2,780 mg/kg. It is expected that a two-stage water wash would further reduce the arsenic concentration to below the more stringent action level of 20 mg/kg. If, during final design, it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to below 20 mg/kg, extraction of arsenic using sodium citrate could be implemented. The treatability studies indicated that sodium citrate would extract arsenic from the sediment to a concentration of 21 mg/kg. This process could be optimized to achieve the action level of 20 mg/kg.

Based on the treatability test and on other information gathered in the RI, it was assumed that the leachate from the coarse washed sand would contain a low enough arsenic concentration to enable the coarse sand to meet substantive delisting requirements and be disposed of as nonhazardous material. The separated water and fine particles containing arsenic could then be treated with subsequent technologies to remove/fixate the arsenic. Because of its effectiveness in lowering the arsenic concentration in the washed sediments, this technology is retained for further evaluation. The delisting criteria for these sediments will be explained in detail in Section 3.0.

o Fixation

Description: Fixation is a chemical process whereby contaminated sediments are converted into a stable cement-type matrix containing minimal free water. Cement, lime, fly ash, sodium silicate, organic polymers, pozzolan, and asphalt can be used to bind or hydrate the free water available in the dredged

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sediments. Commercial proprietary agents are available for both organic and inorganic contaminant fixation. The contaminated sediment treated with any of these agents develops properties ranging from a loose sand or gravel to a weak concrete. The stable end product does not leach appreciable amounts of arsenic and can normally be classified as a nonhazardous material if it meets substantive delisting requirements.

Initial Screening: Bench-scale fixation tests were performed on sediment samples using a commercial silicated blend known as K-20/LSC (manufactured by Lopat Enterprises). Carbon powder, Portland cement and fly ash were also tested as fixation agents. The fixation formulations used were designed to produce fixated solids with leachates (produced from an EP Toxicity Test) of less than 5 mg/l of total arsenic. The tests achieved a level of approximately 1 mg/l arsenic in the leachate, much lower than the target level. The tests were not optimized to achieve a further reduced leachate concentration, although the vendor indicated that a more optimized leachate could be achieved.

Delisting criteria for classification of solids as RCRA nonhazardous material require that a leachate from an EP Toxicity Test have a contaminant concentration less than that computed from the USEPA's VHS model (USEPA, 1985d). For the sediment under consideration the leachate must be less than 0.32 mg/l arsenic. The treatability tests achieved a leachate of 0.800 mg/l arsenic using a 1:1 formulation ratio (chemicals : sediment). By modifying the formulation ratio, it is believed that the sediments could be fixated to produce an EP Toxicity extract of less than 0.32 mg/l arsenic. Therefore this technology is retained for further consideration. Additional treatability tests would be required to confirm/optimize the formulation ratio. The delisting requirements are discussed in detail in Section 3.0.

Physical Treatment - Sediment

Physical treatment processes are applicable for handling sediments from dredging operations both to thicken and dewater the sediments for subsequent treatment and disposal. Physical treatment processes are also applicable for treatment of the supernatant water to allow discharge to Union Lake.

Physical treatment processes evaluated for handling sediments include: hydroclones, gravity thickeners, drying beds, sedimentation basins/lagoons, dehydro drying beds, ultrasonic dewatering, centrifuges, filter presses, vacuum filters, and belt filter presses. Physical treatment processes evaluated for supernatant water treatment include: clarification, filtration, ion exchange, reverse osmosis, and adsorption.

- <u>Hydroclones</u>

  <u>Description</u>: Hydroclones can be used to separate heavy (i.e., large diameter) particles from fines (i.e. small-diameter particles) that are present in the sediments. The sediment is diluted with water to produce a slurry of approximately 20% solids. The slurry is pumped under moderate pressures of 10 to 20 psig, into the hydroclone at a tangential angle. The high rotational flow in the hydroclone causes the larger particles to move towards the wall by centrifugal forces and downward to the apex. Proper selection of the size and operating pressure can induce the concentration of large (i.e., sand) particles in the underflow while the fines concentrate only slightly in the underflow (i.e., pounds fine/pounds water in underflow is only slightly greater than the pounds fines/pounds of water in the feed). The underflow is high in solids (i.e., 40% to 50%) and has a much lower water flow than the overflow. Therefore most of the fines leave the hydroclone in the overflow stream.

  <u>Initial Screening</u>: Hydroclones are a feasible technology for separating fines from larger particles in slurry streams. Based on the data collected in this RI/FS, it is believed that the fines in the sediments contain the majority of arsenic, while the coarse size fraction contains little arsenic. This process is therefore retained for further consideration.

- <u>Drying beds</u>

  <u>Description</u>: Drying beds could be utilized to gravity-drain free liquids from sediments, through a permeable layer. Sediment drying can be accomplished at a relatively low cost and in a reasonable amount of time using, for example, sand beds. The sand drying beds consist of an upper layer of sand and a lower layer with an underdrain system. Local climate such as temperature, precipitation, sunshine and humidity will affect the drying efficiency. It is possible to obtain 45 percent solids content or more in two weeks.

  <u>Initial Screening</u>: Sediment dewatering using drying beds is labor-intensive and requires a significant land area. Since the feasible sediment treatment technologies for the site, such as extraction and fixation, would not require a high degree of dewatering, drying beds are considered not practical

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relative to other available dewatering and thickening technologies. Therefore drying beds are eliminated from further consideration.

- <u>Gravity Thickeners</u>

  <u>Description</u>: Gravity thickeners are similar to conventional circular clarifiers except that they have a greater slope and are constructed with a heavier raking and pumping mechanism. The dredged sediment slurry would enter the center of the thickener unit and solids would settle into a sump at the bottom. The solids would be removed for treatment or disposal, and the supernatant would flow from the overflow weir to a treatment unit.

  <u>Initial Screening</u>: Gravity thickeners are a feasible technology for thickening the sediment prior to extraction or fixation treatment, as demonstrated in the bench-scale tests. This process is implementable and effective, and is therefore retained for further evaluation.

- <u>Sedimentation Basins/Lagoons</u>

  <u>Description</u>: Sedimentation basins and lagoons are two of the oldest and simplest processes for dewatering solids. Common design practice would use a two-lagoon or sedimentation basin system; as one is being filled, the other is being emptied. The side slopes and bottoms of the basins would be lined to prevent leakage. Sediments would be retained in the basin while the supernatant would be decanted and pumped away for treatment. The solids would be collected for further treatment and disposal.

  <u>Initial Screening</u>: Sedimentation basins and dewatering lagoons are not practical for sediment dewatering due to the site-specific conditions. Dredging will be performed over the perimeter of Union Lake, therefore a mobile-type facility (such as a gravity thickener) is preferred. A permanent station (basin) would require an additional booster pump to pump the sediment from the dredge barge to the station. These technologies are not considered implementable and are eliminated from further consideration.

- <u>Dehydro Drying Beds</u>

  <u>Description</u>: This technology is similar to a regular drying bed except that a flocculant is added to the dredged sediment slurry and the water is then filtered through a permeable mat by means of a vacuum system.

The settling of dredged sediments can be accelerated by using this process. This method requires that the contaminated sediment and associated dredge slurry be evenly distributed over the permeable mats. The water is then drawn through the bed aided by a vacuum. The supernatant is collected in a sump and removed or stored for eventual treatment. Approximately 90% of the water in the dredged material can be removed by this process. The dehydro drying beds are a relatively new concept utilizing conventional technical practices.

Initial Screening: Dehydro drying beds perform a high degree of dewatering and can improve drying bed dewatering efficiency. Based on the same criteria discussed for conventional drying beds, dehydro drying beds are considered not practical for this site relative to other available dewatering and thickening technologies. Therefore this modified drying bed technology is eliminated from further evaluation.

o Ultrasonic Dewatering

Description: This system uses ultrasonic vibrations to remove water from solids. This technique is a new technology that has limited documented success. Its applicability to dewatering sediments with high organic content is not known; however, this technology has been used in the mining and processing industry.

Initial Screening: Because of the unknown applicability to sediments with high water and organic contents, and the limited availability of the technology, this remedial technology is eliminated from further consideration.

o Centrifuge

Description: Centrifugal dewatering is a process that uses the force developed by fast rotation of a cylindrical drum or bowl to separate solids and liquids according to their density differences under the influence of centrifugal force. Centrifuges can be used to dewater or concentrate soils and sediments ranging in size from fine gravel down to silt. The effectiveness of centrifugation depends upon the particle size and shapes, and the solids concentration, among other factors.

Initial Screening: Centrifugation is a feasil technology for thickening and dewatering dredged sec ments and excavated soils. It may also be applicat for separating fine and coarse particles in t sediments by operating the centrifuge in a manner th results only in the capture of coarse solids. Th technology is retained for further consideration.

- Filter Press (Plate and Frame)

  Description: Filter presses may be used to dewater sediments by forcing sediments under pressure into a series of plates and chambers fitted with a fine filter cloth. Water is forced through the filter cloth into a collection system, and the plates are then separated and the solids removed for treatment and/or disposal. The system is operated on a batch basis.

  Initial Screening: This dewatering technology is labor intensive and not practical for dewatering sediments at the site due to relatively high operation and maintenance costs, as well as a very limited unit capacity. Therefore this technology is not retained for further evaluation.

- Vacuum Filter

  Description: Vacuum filters are commonly used to dewater sludges from wastewater treatment systems. Vacuum filters utilize a rotating cylinder with an internal vacuum to draw water through the filter medium while leaving solids as a layer on the filter cloth. The dewatered solids are continuously scraped off the rotating filter medium to a conveyor system.

  Initial Screening: Vacuum filtering is a feasible technology for dewatering sludges generated from the supernatant or extractant treatment system. This technology is therefore retained for further evaluation.

- Belt Filter Press

  Description: The belt filter press uses two vertically or horizontally moving belts to squeeze water from the solids. Belt filters have been commonly used for sludge dewatering, which requires preconditioning such as the addition of a coagulant and/or a polymer. Sludges containing fine particles would require preconditioning to improve the dewatering efficiency.

  Initial Screening: Belt filter presses accomplish the same goals as vacuum filters; however, vacuum filters are more efficient for nonfiber or high-viscosity sludge. Therefore this technology is eliminated from further consideration.

In Situ Treatment Technologies

The contaminated sediments to be remediated are located i shallow water areas in Union Lake (less than 5 feet deep). Th implementation of in situ fixation and treatment technologie

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for the sediments would require intensive isolation and dewatering of the sediments and would result in higher costs and a longer construction period. The long-term stability of the treated sediments would be reduced significantly under the dynamic water environment. The following chemical and physical in situ treatment technologies outlined in Table 2-2 were screened relative to their potential applicability and feasibility to cleanup the contaminated sediments.

In Situ Chemical Treatment

The in situ chemical treatment technologies considered involve the introduction of an agent that either (a) removes the arsenic from the in place sediments or (b) binds it to the sediments in such a way that the arsenic is no longer available or capable of being leached and resuspended.

- Extraction

  Description: The sediment is washed with some appropriate acid, alkali, or other solvent to dissolve or solubilize the arsenic. The area to be treated must be isolated by a cofferdam and dewatered with pumps. This enclosure is then flooded with a solvent using hydraulic sprayers. The sediment and solvent are then mixed using adequate agitators such as plows, harrows and rotary tillers. The elutriate (solvent containing the arsenic) is then collected from the isolated area and is pumped to a treatment system.

  Initial Screening: Most of the sediments in Union Lake are composed of organic silts. The in situ water extraction would resuspend the fine particles and would result in pumping a large quantity of sediment with the elutriate to the treatment system. The treatability studies showed that these fines were not easily removed from the extractant solution. This site-specific condition would make in situ extraction no more attractive than on-site extraction. It would be very difficult to implement this technology. Thus construction costs would be higher and construction duration would be longer. Therefore in situ extraction is not considered a practical technology for the site and is eliminated from further evaluation.

- Grout Injection

  Description: The contaminated sediments are solidified by injecting a mixture of Portland cement, fly ash, activated carbon and proprietary chemicals. The mixture traps the sediments into an insoluble matrix. The mixture can either be injected into closely spaced

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holes in the sediment to create vertical columns of solidified material or injected into the top layer of the sediment, while simultaneously being mixed in with rotary tillers to form a whipped layer of solidified material. The areas to be treated would be isolated by a cofferdam and dewatered with pumps, thus the moisture of sediments could be controlled in an effective range. In general, the in situ fixation is more difficult than the on-site removal/fixation, particularly for the sediments under water.

<u>Initial Screening</u>: Due to the difficulty in obtaining moisture control for the in situ sediment fixation, it is difficult to assess how effectively the grout will penetrate the sediment and how long the grout will remain intact. Also, because of the high organic content of the sediment and the dynamic water environment, the long-term stability of grout-injected sediment is unknown. Due to the uncertainties and technical problems with this technology, it is removed from further evaluation.

<u>In Situ Physical Treatment</u>

There was only one physical in situ treatment technology selected for initial screening.

- <u>Vitrification</u>

  <u>Description</u>: In situ vitrification (ISV) is a thermal treatment process utilized to stabilize chemically contaminated soils in place. ISV destroys organic contaminants by pyrolysis and incorporates inorganic contaminants into a glass-like material that essentially renders these contaminants immobile. ISV involves placing electrodes and a graphite/glass mixture in a cross pattern in the sediment, then heating the sediment to molten temperatures by applying a voltage to the electrodes. As the surrounding sediment melts, it becomes electrically conductive. The resulting vitrified solid mass should be very leach-resistant and durable. This process is quite costly and thus has been restricted to the treatment of radioactive or very highly toxic wastes.

  <u>Initial Screening</u>: In situ vitrification is still an emerging technology, but it is known that if the materials to be treated have a high water content, ' effectiveness is reduced and the costs significan increase. It is unlikely that ISV can be used to tr sediments under water. The technology is conside unimplementable and unreliable and is thus elimin from further consideration.

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2.4.1.4 On-Site or Off-Site Disposal Technologies

If one or more of the treatment technologies which incorporate removal in Subsection 2.4.1.3 are incorporated into potential alternatives, then disposal of the removed sediments and any by-product sludges must also be addressed. The requirements for disposal can be divided into two categories, depending on whether the sediments are still hazardous or have been treated so as to be delistable as nonhazardous materials. Nonhazardous materials can be further categorized as either wastes, or useful and marketable materials. There are two general locations for disposal, on-site or off-site. The RCRA Land Disposal Restrictions for RCRA characteristic and listed wastes will become effective May 8, 1990. RCRA landfilling of treated sediment that still fails the EP Toxicity Test (or TCLP when enacted) for arsenic may not be feasible after that date without further treatment. The following technologies listed in Table 2-2 represent various combinations of these waste classifications and possible disposal locations.

<u>Hazardous Waste Disposal</u>

Under this category, three different locations are discussed for the ultimate deposition of the contaminated sediments whose arsenic concentrations qualify them as hazardous wastes.

- <u>Construct On-Site RCRA Landfill</u>

  <u>Description</u>: A new RCRA Subtitle C containment facility could be constructed somewhere within the site boundaries to receive the treated sediments that are not delistable. Although permitting requirements under the laws are not required for fund-financed actions under CERCLA (USEPA, 1985a), the landfill would have to be designed with a double liner system; two leachate detection, collection, and removal systems; and a groundwater monitoring system, according to applicable RCRA requirements (USEPA, 1985b).

  According to an interpretation of the "site boundaries" given to USEPA Region II by USEPA Site Policy and Guidance Branch personnel, the "site" consists of the ViChem Plant property and possibly areas immediately adjacent to the plant. While Union Lake itself is considered part of the ViChem Superfund site, a landfill adjacent to Union Lake would not be considered "on-site" since lands adjacent to the lake are not within the "area of contamination". Therefore an "on-site" landfill would consist of a landfill constructed at the ViChem Plant site itself, approximately 10 river miles upstream from Union Lake.

Initial Screening: Although landfilling hazardous waste was and still is widely used as a management practice, it is now being discouraged by the USEPA, which makes obtaining approval for construction of a new facility very difficult. In addition, treatment before landfilling would have to be explored based on the recent land disposal regulations. The disposal facility would be designed to satisfy all the applicable regulations. The Vineland Chemical Plant site is a viable location for an on-site RCRA disposal facility. Although acquisition of site properties may be difficult, this technology is retained for further consideration.

- Construct Off-Site RCRA Landfill

  Description: The construction of a RCRA Subtitle C containment facility could be undertaken at some location in Salem, Cumberland or Putnam Counties. A site in one of these counties would minimize hauling distances while still allowing an adequate siting area in which to define the optimum location of the facility. However, since it would not be located within the CERCLA site, federal and state permits would have to be obtained.

  Initial Screening: The permitting process requires extensive investigations and acceptance by numerous agencies. Important factors affecting the regulatory acceptance would be the definition of site conditions, design, construction, operation, public concerns, closure, and post-closure monitoring. The land disposal restriction regulations prohibit landfilling without treatment after November 1988, thus this technology may not be feasible without treating the sediment. Because of the difficult administrative efforts required to site a new RCRA landfill, this technology is eliminated from further evaluation.

- Existing Off-Site RCRA Landfill

  Description: The waste material could be hauled to an existing RCRA Subtitle C landfill facility already permitted to accept treated material that is not delistable. This provides a straightforward solution to the disposal problem, but unit costs are high due to transport distance and disposal fee structure. In addition, volume limitations at a facility may put a limit on the quantity of waste that can be disposed of in this fashion.

Initial Screening: Off-site disposal in an existing RCRA facility would have minimal long-term public health and environmental impacts. The land disposal restriction regulations prohibit off-site landfilling without treatment after November 1988, thus this technology may not be feasible without treatment of the sediment. This technology is, therefore, retained for consideration in combination with on-site or off-site treatment.

Nonhazardous Waste Disposal

If the arsenic-contaminated sediment can be treated by one of the technologies evaluated in Subsection 2.4.1.3 in order to be delistable and/or classified as nonhazardous, then its disposal would no longer be limited to just a RCRA Subtitle C Facility. The methods for the disposal of nonhazardous sediments are discussed in this category. These methods address the final deposition of the treated sediments, based on their being classified either as waste or as marketable materials.

Disposal of Waste Materials

Treated sediments determined by the NJDEP as being ID 27 wastes (nonhazardous) can be disposed of by the following landfill, ocean dumping, and deposition options:

- Construct On-Site Nonhazardous Landfill

  Description: As discussed in the previous category, a location within the boundaries of the ViChem Plant site would be considered on-site. Because this landfill would accept only what is considered to be nonhazardous waste, the design and operation requirements would be similar to that of a municipal sanitary landfill.

  Initial Screening: Construction of a sanitary landfill with associated reduction in hazardous properties of the wastes may be acceptable to regulatory agencies and the community if the treated material is delistable. Data from the Union Lake RI suggest that the treated (fixated or water wash extracted) material could meet delisting requirements. This option is retained for further evaluation as a potential disposal alternative.

- Construct Off-Site Nonhazardous Landfill

  Description: Somewhere within Salem, Cumberland or Putnam Counties, a new landfill could be sited, designed, constructed, and operated to receive the treated sediments. After being filled, it would be closed and monitored. Since the waste is not hazardous, requirements for the landfill would be less stringent. However, because it would not be located within the CERCLA site, federal and state permits would have to be obtained.

Initial Screening: Again, because of the permitting process, the siting studies, and the public's reluctance to have a landfill sited nearby, this technology is not retained for additional evaluation.

- Existing Off-Site Nonhazardous Landfill

Description: An existing licensed landfill could be used for the disposal of nonhazardous wastes. There would only be disposal costs associated with this technology, and no costs to the remediation associated with the design, operation and maintenance, closure, or monitoring of a new facility. It is assumed that there would be no problems with using an existing landfill facility. Nearby landfills have been contacted and have the capacity to accept the treated material.

Initial Screening: Treated materials may be disposed in nonhazardous landfills and even used as cover material depending upon the delisting classification. Preliminary investigations into the availability of a local landfill willing to accept the treated sediments are encouraging; therefore, this technology is retained for further consideration.

- Ocean Disposal

Description: The disposal of nonhazardous, treated sediments in the Atlantic Ocean can be considered. Barges would haul the treated material to an acceptable disposal location in the Atlantic Ocean and then deposit them there. Permits and the assessment of environmental impacts are important considerations for this technology.

Initial Screening: The current regulations in 40 CFR 220-227 require a long and involved testing process in order to acquire a permit to dispose of the treated sediments in the ocean. Ocean dumping would require ocean-going barges and barge loading facilities to be constructed at or near the site. This would be impractical for Union Lake. The treated sediments would be transported by barge down the lower Maurice River to the Delaware Bay. Local citizen groups have protested other barge traffic planned for the lower Maurice River. Therefore ocean disposal is eliminated from further consideration.

- **Lake Deposition**

  Description: Lake deposition of the treated sediments is a cost-effective disposal alternative. Barges would haul the material to portions of Union Lake and deposit the treated sediment.

  Initial Screening: This disposal activity would trigger RCRA requirements including the land ban. Therefore any material to be deposited in the lake would require delisting. Data from the Union Lake RI suggest that the treated material may be delistable. Following delisting and the determination that the treated sediments are not ID 27 waste, deposition would take place. Therefore this technology is retained for further evaluation.

- **Plant Site Deposition**

  Description: Plant site deposition of the treated sediments is a cost-effective disposal alternative. The treated sediments would be deposited in undeveloped areas of the plant site. Trucks would haul the treated sediments to locations within the approximate 17-acre available land area. Bulldozers and graders would compact and grade the treated sediment.

  Initial Screening: This disposal activity would also invoke RCRA requirements, including land disposal restrictions. As discussed previously, any material to be deposited on the site would require delisting and a determination that the treated sediments are not ID 27 waste. Control measures would be instituted to monitor the effectiveness of the treatment. The effectiveness of this disposal option is expected to be high, thus it is retained for further evaluation.

Final Deposition of Usable Materials

Treated sediments not classified by the NJDEP as ID 27 wastes can be considered marketable materials with the following option:

- **Construction Aggregate**

  Description: Treated sediments would be hauled to nearby construction material vendors and used as aggregate in suitable applications. These applications could range from fill for highway construction to bed material for lagoons. The physical characteristics of the material following treatment and the vendor's ability to render it suitable to a specific need would dictate the effectiveness of this option.

Initial Screening: This option would be facilitated by delisting treated sediments and subsequently identifying beneficial uses for them. Since a substantial cost savings could be realized by implementing this alternative for utilization of the treated material, it is retained as a process option when evaluating remedial alternatives.

Chemical Treatment - Water

The supernatant water associated with the sediments that would be removed by dredging would require arsenic, iron and suspended solids removal prior to discharge to Union Lake. In addition, the extractant generated from the water extraction process also would require arsenic and suspended solids removal. Suspended solids removal would in turn remove the arsenic associated with the suspended solids. Arsenic and suspended solids removal can be achieved by chemical coagulation/flocculation/precipitation. Other technologies screened include biodegradation, oxidation and neutralization/pH adjustment.

- Coagulation/Flocculation/Precipitation

  Description: Chemical coagulation/flocculation/precipitation is the addition of chemicals such as ferric chloride, lime, sulfide and polymers to precipitate metals and suspended solids from solution. Flocculation is the gentle agitation of the coagulated solids to promote the growth of floc particles to increase precipitation rates and removal.

  Initial Screening: This process is used primarily in conventional wastewater treatment systems to remove suspended solids. Ferric chloride precipitation is the key unit operation for arsenic removal at the existing ViChem wastewater treatment plant. Therefore chemical coagulation/flocculation/precipitation is retained for further evaluation.

- Biodegradation

  Description: Biodegradation utilizes bacteria or other microbes to biologically oxidize or reduce contaminants by converting the organics to carbon dioxide, water, methane and a new cellular biomass. Proper control of the treatment environment (pH, nutrients, temperature and oxygen) is critical to the reproduction and growth of the microbes. However, bacteria and microbes used for one contaminant may be inhibited by the presence of another contaminant.

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Initial Screening: The bench-scale treatability tests for the sediment arsenic extraction indicated that the extractant contained a large amount of very fine suspensions, high in organic content. It is believed that these fine particles can be settled out of solution by a combination of coagulation/flocculation/precipitation. Therefore there is no reason to biologically treat the water extractant solution containing the fines, thus eliminating biodegradation from further consideration.

- Oxidation

Description: Chemical oxidation is utilized to change the chemical form of a hazardous material to render it less toxic, or to change its solubility, stability, or separability, or otherwise change it for handling or disposal purposes. Oxidizing agents would include hydrogen peroxide, potassium permanganate, ozone, sodium hypochlorite and calcium hydrochlorite.

Oxidation processes can be used to treat diluted wastewater containing oxidizable organics and can also be used as an effective process for pretreating wastes prior to biological treatment.

Initial Screening: The ViChem wastewater treatment plant has utilized potassium permanganate oxidation to oxidize organic arsenic (mainly monomethyl arsenic acid and dimethyl arsenic acid) to arsenate. Oxidation also converts most of the arsenite into arsenate. Arsenate is the form of arsenic that is most effectively removed by chemical coagulation, flocculation and precipitation. Chemical oxidation is effective and implementable, and is therefore retained for further evaluation.

- Neutralization/pH Adjustment

Description: Neutralization is a process used to adjust the pH (acidity or alkalinity) of a waste stream to an acceptable level for discharge, usually between 6.0 to 9.0 pH units. Neutralization may also be used as a pre- or post-treatment step with other treatment processes i.e., chemical precipitation. Adjustment of pH is done by adding acidic reagents to alkaline streams and vice versa.

- Initial Screening: Neutralization is a conventional and widely demonstrated means of adjusting the pH of a waste before and/or after chemical oxidation and precipitation. For this reason, neutralization is retained for further evaluation, if required as part of a chemical treatment system.

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Physical Treatment - Water

Physical treatment processes that were screened for the liquid wastes generated from thickening, dewatering or extracting processes include clarification, filtration, ion exchange, adsorption and reverse osmosis.

- Clarification

  Description: The primary function of clarification is to remove settleable suspended solids to produce a clear waste stream. The clarifier is equipped with a solids removal device to facilitate clarification on a continuous process basis, resulting in a lower solids content for the effluent. Clarifier performance is based on the settling characteristics of the sediment and the design criteria.

  Initial Screening: Clarification, which is a sedimentation process, has been shown in the bench-scale studies to be applicable for removing suspended solids in the dredged supernatant. This technology, therefore, is retained for further evaluation.

- Filtration

  Description: Filtration is used to remove organics and solids that are not settleable. The use of different media is possible, the most common being sand filtration or mixed media filters, which include sand and anthracite. Sand filtration is typically used after clarification to remove nonsettleable solids. A mixed-media filtration system consists of a layer of anthracite and a layer of sand to effect the filtration and adsorption of fine particles. This type of filter media would selectively remove the insoluble particles that are present in the suspended solids of the supernatant.

  Initial Screening: Filtration is applicable to the removal of nonsettlable suspended solids and is retained for further evaluation.

- Ion Exchange

  Description: Ion exchange is a process whereby the toxic ions are removed from the aqueous phase by electrostatic exchange with relatively harmless ions that are held by ion exchange resins. Ion exchange is used to remove metallic cations and anions, inorganic anions, organic acids and organic amines. Fixed bed and countercurrent systems are the most widely used ion

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exchange systems. The continuous countercurrent systems are suitable for high flows. The strong base anion exchange resins are the most effective resins for arsenic removal.

Initial Screening: Bench-scale tests indicated that the strong base anion exchange resins in chloride form (Amberlite IRA-400 and Dowex AG-I-X8) removed arsenic from the groundwater to below the discharge limit level of 0.05 mg/l. The ion exchange process would be feasible for use as a polishing unit for further arsenic removal following the physical-chemical precipitation process. However, the need for a polishing process unit is not anticipated due to the high solids and subsequent arsenic removal provided by clarification. Thus ion exchange is eliminated from further consideration.

- Adsorption

Description: The process of adsorption involves contacting a waste stream with an adsorbent, usually by flow through a series of packed bed reactors. Adsorption efficiency depends on the strength of the molecular attraction between the adsorbent and the adsorbate, molecular weight, type and characteristics of adsorbent, electrokinetic charge, pH and surface area. Activated carbon has been demonstrated to be an ineffective adsorbent for arsenic removal from aqueous wastes (Lee, 1982), whereas activated alumina has been shown to be an effective adsorbent for arsenic-contaminated wastewater.

Initial Screening: The bench-scale treatability studies performed in the RI indicated that activated alumina adsorption displayed a much better arsenic removal efficiency than activated carbon adsorption. Activated alumina adsorption could be used as a polishing process for physical-chemical treatment for the water extractant solution, but as discussed under ion exchange, the need for a polishing unit is not anticipated. Therefore adsorption is eliminated from further consideration.

- Reverse Osmosis

Description: Reverse osmosis is the application of sufficient pressure to the concentrated solution to overcome the osmotic pressure and force the net flow of water through the membrane toward a dilute phase. This allows the concentration of solute (impurities) to be built up in a circulating system on one side of the membrane, while relatively pure water is transported through the membrane. Ions and small molecular compounds in true solution can be separated from water by this technique. The basic components of a reverse osmosis unit are the membrane, a membrane support structure, a containing vessel and a high pressure pump. The semipermeable membrane can be flat or tubular, but regardless of its shape it can act like a filter due to the pressure-driving force.

Initial Screening: The bench-scale treatability studies indicated that reverse osmosis could be used to remove arsenic from the contaminated supernatant and to produce an effluent with a total arsenic concentration below 0.05 mg/l. However, this process generated an extremely high volume of reject stream and required a very high operating pressure. In addition, the membrane must be compatible with the waste stream's chemical and physical characteristics. Suspended solids and some organics will clog the membrane material, and low-solubility salts may precipitate onto the membrane surface. Therefore, reverse osmosis is not a practical or economical technology for the liquid extractant treatment and is eliminated from further consideration.

Off-Site Wastewater Treatment

o POTW and Industrial Wastewater Treatment Plant

Description: Under this technology, the sediment supernatant or extractant would be piped to a publicly owned treatment works (POTW) or an industrial facility for treatment and discharge. At present, a hookup to the local POTW or an industrial treatment plant does not exist. A new piping system would have to be constructed to transport the wastewater to the area sewer system or directly to the industrial treatment plant.

Initial Screening: The City of Vineland Sewage Treatment System near Union Lake was contacted with regard to accepting the wastewater. They indicated that their system does not have the extra capacity or the adequate treatment processes to handle the large volume of arsenic contaminated wastewater. Therefore the off-site POTW technology is infeasible and is eliminated from further evaluation.

The only nearby industrial waste treatment plant is the ViChem wastewater treatment plant. This plant would not have the extra capacity to handle the supernatant or extractant flow. In addition, the existing ViChem wastewater treatment plant cannot produce an effluent with arsenic below the discharge limit of 0.05 mg/l. Therefore this disposal option is eliminated from further consideration.

2.4.1.5 Transportation Technologies

In association with the optional off-site disposal technologies screened in Subsection 2.4.1.4, complementary modes of transportation must also be considered. The following methods of transportation were selected for this screening process.

- Truck

  Description: There is limited road access to the site. Trucks would probably be used to bring in equipment and materials for remediation. In addition, watertight trucks or tanker trailers could be used to haul and transport sediment and treatment sludge. Trucks would be properly decontaminated, weighed, and manifested before leaving the site. Stringent regulations and special permits for hauling hazardous materials, and oversized and heavy loads over public highways would have to be taken into consideration.

  Initial Screening: This is a highly acceptable mode of transportation. The operation is flexible, since the number of trucks being utilized can be increased or decreased depending upon the requirements. The mode of transportation does not require special loading facilities at the project site or unloading facilities at the disposal site. Trucks are therefore retained for further evaluation.

- Pipeline

  Description: A pipeline system consisting of pipes or tubing could be used to convey materials. It can be used to handle both liquids and solids; however, the solids must be in a slurry form with a water content of at least 40-60 percent. Hydraulic dredging technologies produce such a slurry, requiring a pipeline to carry the sediments to a dewatering device. A pipeline can be a very costly system, especially if booster pump stations are required to overcome steep changes in elevations and pumping distances.

  Initial Screening: A pipeline to the disposal site only for the duration of the construction period would be extremely expensive. In addition, routing of this pipeline through various towns and along the roads would require numerous permits. This technology is eliminated for the disposal option. However, pipelines that are an integral part of a remediation process for conveying dredged/treated material from one unit to another unit are retained for further consideration.

2.4.2 Selection of Representative Technologies

Table 2-3 presents the results of the evaluation of various technologies performed in this section and the selection of representative technologies. This table identifies those technologies that are not feasible and have been eliminated from further evaluation. The table also identifies the technologies that will be combined into remedial alternates and further evaluated in Section 3.0.

TABLE 2-3
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
NO ACTION	NONE	NOT APPLICABLE	NO ACTION	REQUIRED FOR CONSIDERATION
CONTAINMENT OF SEDIMENT	CAP	CLAY	COMPACTED CLAY OVER AREAS OF CONTAMINATION	NOT FEASIBLE UNDER SUBMERGED LAKE SEDIMENTS,BUT IS SUITABLE FOR LANDFILL
		SYNTHETIC MEMBRANE	SYNTHETIC MEMBRANE OVER AREAS OF CONTAMINATION	POTENTIALLY APPLICABLE FOR USE W/MULTILAYER CAP
		CHEMICAL SEALANTS	CHEMICALS OR CEMENT FORM STRONGER AND LESS PERMEABLE SURFACE	SUBJECT TO LAKE EROSION AND CRACKING. ALSO APPLICABILITY IN WATER IS UNKNOWN
	COVERING	FILTER FABRIC	WOVEN MATERIAL PLACED OVER SEDIMENTS TO LIMIT MOVEMENT	NOT FEASIBLE BECAUSE IT IS SUBJECT TO BIOTA ATTACK AND REQUIRES CONTINUAL MAINTENANCE
		COARSE SAND	COARSE SAND COVER PLACED OVER CONTAMINATED SEDIMENTS	POTENTIALLY APPLICABLE
		STONE/GRAVEL	STONE OR GRAVEL PLACED OVER CONTAMINATED SEDIMENTS	SUBJECT TO LAKE EROSION, MAY NOT PREVENT PLANT GROWTH, AND DOES NOT PREVENT ARSENIC LEACHING
	BARRIER	SILT CURTAIN	MADE FROM FILTER FABRIC AND SUSPENDED BY FLOATS OR STAKED INTO SEDIMENT TO REDUCE TRANSPORT	WOULD BE EFFECTIVE IN MINIMIZING RESUSPENDED PARTICLE MIGRATION
		DIKES/PIERS	EARTH AND ROCKFILLED STRUCTURES USED TO ISOLATE AREAS FROM CONTAMINATION	ADVERSELY IMPACTS THE LAKE HYDRAULICALLY AND MAY CAUSE BACK-WATER FLOODING AND SCOURING
		SHEET PILING	DRIVE SHEET PILE AROUND AREAS OF CONTAMINATION	NOT REQUIRED SINCE SEDIMENTS CAN BE REMOVED BY DREDGING

TABLE 2-3 (CONTINUED)
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
TREATMENT OF SEDIMENT	COMPLETE OR PARTIAL REMOVAL	EXCAVATION	EXCAVATION OF SEDIMENTS IN LAKE AFTER DRAWDOWN IS COMPLETED.	A LOW GROUND PRESSURE BACKHOE CAN EXCAVATE LAKE SEDIMENTS, AND BULLDOZERS AND FRONT-END LOADERS CAN PROVIDE SUPPORT
		MECHANICAL DREDGING	CLAMSHELL OR BUCKET LOADERS MOUNTED ON BARGES EXCAVATE SEDIMENTS IN-PLACE	REQUIRES WATER DEPTH OF AT LEAST FIVE FEET AND CAUSES RESUSPENSION OF SEDIMENTS
		HYDRAULIC DREDGING	UTILIZES WATER TO TRANSPORT SEDIMENTS AS A 10 TO 20% WEIGHT SLURRY. FOUR TYPES OF HYDRAULIC DREDGES ARE COMMERCIALLY AVAILABLE	SUCTION/DUSTPAN, CUTTERHEAD AND HOPPER DREDGES CANNOT OPERATE IN 2.5' OF WATER. PORTABLE HORIZONTAL AUGER CUTTER DREDGES ARE SUITABLE FOR USE
		PNEUMATIC DREDGING	USE COMPRESSED AIR AND HYDROSTATIC PRESSURE TO DRAW SEDIMENTS TO A COLLECTION HEAD AND THROUGH A TRANSPORT PIPE	SOME UNITS REQUIRE A MINIMUM DEPTH AND ARE CURRENTLY BEING EVALUATED
	THERMAL TREATMENT	INCINERATION	TREATMENT WILL EVAPORATE WATER, DESTROY ORGANIC MATTER, AND VAPORIZE VOLATILE METALS	NOT FEASIBLE DUE TO INORGANIC ARSENIC CONTAMINATION
		WET OXIDATION	ELEVATED TEMPERATURE AND PRESSURE ARE USED TO OXIDIZE ORGANIC COMPOUNDS	NOT APPLICABLE TO SOLIDS AND INORGANIC CONTAMINANTS
	CHEMICAL TREATMENT	ACIDIFICATION/ ALKALIZATION	AN ACID OR AN ALKALI ARE MIXED WITH SEDIMENT TO SOLUBILIZE AND LEACH ARSENIC INTO SOLUTION	TREATABILITY TESTS SHOWED THIS TECHNOLOGY WAS NOT FEASIBLE
		EXTRACTION	EXTRACTION OF CONTAMINANT USING WATER, SOLVENT, WETTING AGENT,OR ANY COMBINATION OF THE THREE	TREATABILITY TESTS SHOWED THIS TECHNOLOGY TO BE FEASIBLE
		FIXATION	CHEMICAL PROCESS THAT CONVERTS CONTAMINATED SOIL INTO A CEMENT MATRIX WITH MINIMAL FREE, UNLEACHABLE WATER	TREATABILITY TESTS SHOWED THIS TECHNOLOGY TO BE POTENTIALLY FEASIBLE

TABLE 2-3 (CONTINUED)
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
TREATMENT OF SEDIMENT	PHYSICAL TREATMENT	HYDROCLONES	SLURRIES ARE PUMPED TANGENTIALLY INTO THE HYDROCLONE CAUSING MOST LARGE PARTICLES TO BE TRANSPORTED TO THE WALL AND OUT THE BOTTOM. MOST OF THE WATER AND FINES LEAVE AT THE TOP	FEASIBLE FOR SEPARATING FINES CONTAINING HIGH ARSENIC CONTENT FROM THE LARGE SANDY MATERIAL IN THE SEDIMENTS
		DRYING BEDS	LIQUIDS ARE SEPARATED FROM THE SEDIMENTS BY GRAVITY DRAINING THROUGH A PERMEABLE LAYER	REQUIRES A LARGE LAND AREA AND IS LABOR INTENSIVE. OTHER TECHNOLOGIES ARE MORE SUITABLE
		GRAVITY THICKENERS	SIMILAR TO CIRCULAR CLARIFIERS BUT HAVE A STEEPER SLOPE AND HEAVIER RAKING AND PUMPING MECHANISM	CAN BE USED TO THICKEN SEDIMENTS PRIOR TO EXTRACTION OR FIXATION
		SEDIMENTATION BASINS/LAGOONS	A LINED BASIN/LAGOON IS FILLED WITH SEDIMENT/SLURRY AND AFTER SUFFICIENT TIME THE SUPERNATANT IS PUMPED OUT	THIS IS IMPRACTICAL TO IMPLEMENT BECAUSE THE EXCAVATION IS AROUND THE ENTIRE PERIMETER OF THE LAKE
		DEHYDRO DRYING BEDS	SIMILAR TO REGULAR DRYING BEDS BUT A FLOCCULANT MIXER WITH SEDIMENT SLURRY AND A VACUUM IS USED TO PULL THE WATER THROUGH A PERMEABLE MAT	REQUIRES A LARGE LAND AREA AND IS LABOR INTENSIVE. OTHER TECHNOLOGIES ARE MORE SUITABLE
		ULTRASONIC DEWATERING	ULTRASONIC VIBRATIONS ARE USED TO REMOVE WATER FROM SOLIDS	THE APPLICABILITY OF THIS TECHNOLOGY TO SEDIMENTS WITH A HIGH ORGANIC CONTENT IS UNKNOWN
		CENTRIFUGE	CENTRIFUGAL FORCE SEPARATES SOLIDS FROM LIQUIDS BY DENSITY DIFFERENCES	FEASIBLE FOR SEPARATING FINES CONTAINING HIGH ARSENIC CONTENT FROM THE LARGE SANDY MATERIAL IN THE SEDIMENTS
		FILTER PRESS	SEDIMENTS ARE FORCED UNDER PRESSURE AGAINST A FINE CLOTH THAT PERMITS THE WATER TO PASS THROUGH	THIS TECHNOLOGY IS VERY LABOR INTENSIVE AND HAS A LIMITED CAPACITY
		VACUUM FILTER	A ROTATING CYLINDER WITH AN INTERNAL VACUUM PULLS WATER THROUGH A FILTER CLOTH LEAVING THE SOLIDS ON THE OUTSIDE	FEASIBLE TECHNOLOGY FOR DEWATERING SEDIMENTS
		BELT FILTER PRESS	A HORIZONTALLY OR VERTICALLY MOVING BELT USES VACUUM AND/OR ROLLERS TO PULL WATER THROUGH THE BELT	THIS ACCOMPLISHES THE SAME RESULT AS THE VACUUM FILTER BUT IS MORE COSTLY

TABLE 2-3 (CONTINUED)
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
TREATMENT OF SEDIMENT	IN SITU TREATMENT	IN SITU EXTRACTION	AREA TO BE TREATED IS ISOLATED, DEWATERED BY PUMPING AND FLOODED WITH A SUITABLE SOLVENT TO DISSOLVE THE ARSENIC	DIFFICULT TO IMPLEMENT AT AT THE SITE
		GROUT INJECTION	SEDIMENTS ARE SOLIDIFIED BY BLENDING WITH A CEMENTATION MIXTURE	NOT SUITABLE FOR SEDIMENTS WITH HIGH ORGANIC CONTENT
		VITRIFICATION	ELECTRODES AND A GRAPHITE GLASS ARE PLACED ON A GRID AREA AND ARE USED TO VITRIFY THE SEDIMENTS WITH A HIGH ELECTRIC VOLTAGE	NOT SUITABLE FOR SEDIMENTS WITH A HIGH WATER CONTENT
DISPOSAL OF SEDIMENT AND SLUDGE	ON-SITE DISPOSAL	CONSTRUCT ON-SITE RCRA LANDFILL	CONSTRUCT NEW RCRA SUBTITLE C LANDFILL ON THE PLANT SITE	THIS IS FEASIBLE BECAUSE THE NECESSARY LAND IS PROBABLY AVAILABLE AT THE PLANT SITE
		CONSTRUCT ON-SITE NONHAZARDOUS LANDFILL	CONSTRUCT NEW NONHAZARDOUS LANDFILL ON THE PLANT SITE	THIS IS FEASIBLE BECAUSE THE NECESSARY LAND IS PROBABLY AVAILABLE AT THE PLANT SITE
		LAKE DEPOSITION	TREATED SEDIMENTS ARE DEPOSITED IN THE DREDGED/EXCAVATED AREAS OF THE LAKE	POTENTIALLY FEASIBLE FOR DELISTED SEDIMENTS
		PLANT SITE DEPOSITION	TREATED SEDIMENTS ARE DEPOSITED ON THE PLANT SITE	POTENTIALLY FEASIBLE FOR DELISTED SEDIMENTS

TABLE 2-3 (CONTINUED)
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
DISPOSAL OF SEDIMENT AND SLUDGE	OFF-SITE DISPOSAL	CONSTRUCT OFF-SITE RCRA LANDFILL	CONSTRUCT RCRA LANDFILL AT AN OFF-SITE LOCATION TO DISPOSE OF CONTAMINATED SEDIMENTS	DIFFICULT TO IMPLEMENT AND LANDBAN RESTRICTION MAY REQUIRE TREATMENT OF SEDIMENTS
		EXISTING OFF-SITE RCRA LANDFILL	DISPOSE OF CONTAMINATED SEDIMENTS IN AN EXISTING OFF-SITE RCRA LANDFILL	POTENTIALLY APPLICABLE
		CONSTRUCT OFF-SITE NONHAZARDOUS LANDFILL	CONSTRUCT NONHAZARDOUS LANDFILL AT AN OFF-SITE LOCATION TO DISPOSE OF NONHAZARDOUS SEDIMENTS	DIFFICULT TO IMPLEMENT NEAR THE SITE
		EXISTING OFF-SITE NONHAZARDOUS LANDFILL	DISPOSE OF NONHAZARDOUS SEDIMENTS IN AN EXISTING OFF-SITE NONHAZARDOUS LANDFILL	POTENTIALLY APPLICABLE
		OCEAN DISPOSAL	DISPOSE OF SEDIMENTS IN THE ATLANTIC OCEAN	DIFFICULT TO IMPLEMENT AND STRONGLY OPPOSED BY THE PUBLIC
		CONSTRUCTION AGGREGATE	TREATED SEDIMENTS TAKEN TO A CONSTRUCTION FACILITY FOR USE AS CONSTRUCTION MATERIAL	POTENTIALLY APPLICABLE

TABLE 2-3 (CONTINUED)
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
TREATMENT OF PROCESS WATER	CHEMICAL TREATMENT	COAGULATION/ FLOCCULATION/ PRECIPITATION	CHEMICALS ADDED TO SOLUTION TO INCREASE PRECIPITATION RATES OF SUSPENDED FINES	APPLICABLE FOR TREATMENT OF SUPERNATANT FROM THE EXCTRACTION PROCESS
		~~BIODEGRADATION~~	CONTROL THE ENVIRONMENT CHEMISTRY TO PROMOTE BACTERIAL GROWTH TO NEUTRALIZE CONTAMINATION	LIMITED APPLICABILITY FOR TREATING ARSENIC CONTAMINATION AND IT IS NOT REQUIRED TO TREAT THE FINES IN THE LIQUID
		OXIDATION	ADDITION OF OXIDATION AGENTS TO OXIDIZE DISSOLVED SPECIES	APPLICABLE TO OXIDIZING DISSOLVED ARSENIC IN THE SUPERNATANT FROM AN EXTRACTION PROCESS
		NEUTRALIZATION	ADDITION OF ACID OR ALKALI TO ADJUST THE SOLUTION PH TO BETWEEN 6.0 AND 9.0	MAY BE REQUIRED TO TREAT SUPERNATANT FROM AN EXTRACTION OR FIXATION PROCESS
	PHYSICAL TREATMENT	CLARIFICATION	A SETTLING CHAMBER FOR COLLECTION OF SETTLEABLE SUSPENDED SOLIDS	MAY BE REQUIRED TO TREAT PROCESS WATER FROM AN EXTRACTION OR FIXATION PROCESS
		FILTRATION	SAND OR CHARCOAL FILTER IS USED TO FILTER SUSPENDED SOLIDS IN A SUPERNATANT	MAY BE REQUIRED TO TREAT SUPERNATANT FROM AN EXTRACTION OR FIXATION PROCESS
		~~ION EXCHANGE~~	SUPERNATANT IS PUMPED THROUGH A FIXED BED OF ION EXCHANGE RESIN WHICH REMOVES THE IONS IN SOLUTION	THIS TECHNOLOGY IS MAINLY USED AS A POLISHING UNIT WHICH IS NOT REQUIRED
		~~ADSORPTION~~	SUPERNATANT IS PUMPED THROUGH A FIXED BED OF CARBON OR ACTIVATED ALUMINA AND ADSORBS DISSOLVED SPECIES	THIS TECHNOLOGY IS MAINLY USED AS A POLISHING UNIT WHICH IS NOT REQUIRED
		~~REVERSE OSMOSIS~~	PRESSURE APPLIED TO A SOLUTION FORCES WATER THROUGH A MEMBRANE	NOT ECONOMIC OR PRACTICAL FOR DILUTE SOLUTIONS

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TABLE 2-3 (CONTINUED)
SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
DISCHARGE OF PROCESS WATER	OFF-SITE WASTEWATER TREATMENT	POTW OR INDUSTRIAL WASTEWATER TREATMENT PLANT	WASTEWATER SENT TO POTW OR INDUSTRIAL WASTEWATER TREATMENT PLANT	NO POTW CAN ACCEPT THE THE FLOW AND NO INDUSTRIAL WASTEWATER TREATMENT PLANT EXISTS IN THE AREA
	ON-SITE DISCHARGE TO LAKE	PIPELINE TO LAKE	PROCESS WATER IS DISCHARGED TO THE LAKE VIA A PIPELINE	APPLICABLE TECHNOLOGY FOR DISPOSAL OF PROCESS WATER
TRANSPORTATION	TRANSPORTATION TECHNOLOGIES	TRUCK	TRUCKS CAN BE USED TO HAUL SEDIMENTS, SLUDGE AND TO TRANSPORT EQUIPMENT	APPLICABLE AS SUPPORT FOR MANY TECHNOLOGIES BEING EVALUATED
		PIPELINE	USED TO CONVEY SUPERNATANTS OR SLURRIES	APPLICABLE AS SUPPORT FOR MANY TECHNOLOGIES BEING EVALUATED

VIN 002 0327

3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

In this section, the technically feasible remedial technologies identified in Section 2.0 are grouped into potential remedial action alternatives. These alternatives are screened based on effectiveness, implementability and cost considerations. The purpose of the screening step is to identify alternatives that have sufficient merit to undergo detailed evaluation. This is achieved by eliminating remedial alternatives that have significant adverse environmental or public health impacts. Costs may be used to discriminate between treatment alternatives in the screening process, but not between treatment and non-treatment alternatives.

The purpose of the initial screening is to narrow the number of potential remedial alternatives for detailed analysis while preserving a range of options. The discussions and evaluations comprising this screening are not intended as a substitute for or a supplement to the detailed analysis of the alternatives conducted in the next section of this report.

3.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

A remedial action objective has been established for the remedial program for Union Lake. This objective was presented in Section 2.2.

In order to achieve the established remedial action objective, response criteria are first developed to evaluate the acceptability of environmental and public health impacts and the anticipated performance of the alternative. This step establishes ARARs and other appropriate criteria in order to define performance requirements and potential human risks associated with the remedial action. Next, potentially applicable technologies identified in Section 2.0 are used to develop comprehensive medium-specific remedial alternatives on the basis of operation and performance compatibility, and the use of acceptable engineering practices. Finally, the alternatives are evaluated, in a general sense, with respect to effectiveness, implementability and cost criteria. Each step of the process is described in the following sections.

3.1.1 Development of Remedial Response Criteria

This subsection identifies and describes the use of applicable or relevant and appropriate requirements (ARARs) in evaluating the Union Lake remedial alternatives during feasibility studies.

3.1.1.1 Use of ARARs in Remedial Alternative Evaluation

CERCLA did not provide specific guidance on standards that should be utilized to manage uncontrolled hazardous substance sites. The USEPA subsequently developed the ARAR concept to

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govern the Superfund program compliance with other environmental and public health statutes in remedial actions.

Before enactment of the Superfund Amendment and Reauthorization Act (SARA), the USEPA's ARAR guidance was contained in the National Contingency Plan (NCP) and the "Memorandum on CERCLA Compliance with Other Environmental Laws" (the Compliance Policy), which was published as an appendix to the NCP. Section 121 of SARA incorporated the ARAR concept but made several changes. Most importantly, Section 121 designated state requirements as ARARs whenever they are promulgated and identified in a timely manner, and are as strict or stricter than equivalent federal ARARs. SARA also required the attainment of Water Quality Criteria or Maximum Contaminant Levels (MCLs) if they are "relevant and appropriate." On August 27, 1987, USEPA issued an Interim Guidance document addressing the new ARAR provisions (52 Fed. Reg. 32496).

The role of ARARs in the FS process involves evaluating a remedial alternative to characterize the performance level that it is capable of achieving. Each remedial alternative must be assessed to evaluate whether it attains or exceeds federal and state ARARs.

Two types of ARARs exist: "applicable" and "relevant and appropriate" requirements of federal and state laws. An "applicable" requirement is any standard or limitation that is legally binding on a CERCLA site based on the contaminant, remedial action, or location of the site. In other words, applicable requirements are requirements that would apply to response actions even if actions were not taken pursuant to CERCLA. A "relevant and appropriate" requirement is any standard or limitation that, while not applicable to the hazardous substance, action, or location of a CERCLA site, does address problems or situations sufficiently similar to those encountered at the CERCLA site that its use is suited. When establishing performance goals for remedial alternative selection, relevant and appropriate requirements are given equal weight and consideration as applicable requirements.

If no ARAR exists for a CERCLA site situation, other federal and state criteria, advisories, guidance, or proposed rules may be considered for developing remedial alternative performance goals. These "To Be Considered" materials (TBCs) are not legally binding, but may provide useful information or recommended procedures that explain or amplify the content of ARARs. If no ARAR addresses a particular situation, or if existing ARARs do not ensure protection of human health and the environment at a particular site, "To Be Considered" materials (TBCs) should be evaluated for use.

Each type of ARAR can be characterized further as (1) contaminant-specific; (2) action-specific; and (3) location-specific. A contaminant-specific ARAR sets health and risk-based concentration limits in various environmental media for a specific hazardous substance or contaminant. An action-specific ARAR sets performance, design, or other similar action-specific controls on particular remedial activities. A location-specific ARAR sets restrictions on the conduct of activities in particular locations, such as wetlands, flood plains, national historic districts, and others.

3.1.1.2 Identification of ARARs for Union Lake

This section presents a listing and general discussion of the federal and New Jersey ARARs and "To Be Considered" (TBCs) material utilized in this FS.

3.1.1.2.1 Listing of ARARs and TBCs

This listing is organized into the categories described above.

- <u>Contaminant-Specific</u>
  - Federal and New Jersey Drinking Water Maximum Contaminant Levels (MCLs)
  - Federal Clean Water Act Water Quality Criteria
  - New Jersey Surface Water Quality Standards
- <u>Location-Specific</u>
  - U.S. Fish and Wildlife Coordination Act
  - National Endangered Species Act
  - Federal Floodplain and Wetlands Executive Order
  - Federal Floodplains and Wetlands Policy
  - New Jersey Coastal Area Facility Review Act (CAFRA) Permit Requirements
  - New Jersey Wetlands (Coastal and Fresh Water) Permit Requirements
  - River and Harbor Act Section 10/Clean Water Act Section 404 Standards
  - New Jersey Soil Erosion and Sediment Control Requirements

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o Action-Specific

- Federal and New Jersey Hazardous Waste (Resource Conservation and Recovery Act) Treatment/Storage/ Disposal Facility Requirements

- Federal Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR)

- Federal and New Jersey Nonhazardous Waste Landfill Facility Criteria

- Clean Water Act NJPDES Discharge to Surface Water Requirements

- Occupational Safety and Health Act Requirements for Hazardous Responses

- RCRA Characteristic Testing for Hazardous Waste Identification

- Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste

- New Jersey Toxic Substance Air Pollution Standards

- New Jersey Ambient Air Quality Standards

- National Historic Preservation Act

3.1.1.2.2 General Discussions of Key ARARs and TBCs

This subsection presents general discussions of ARARs and TBCs that are the key requirements in remedial alternative evaluation and comparison. The focus of these discussions is on distinguishing between alternatives based upon ARAR/TBC attainment, rather than providing an exhaustive description of the ARARs/TBCs themselves.

o New Jersey Surface Quality Standards and NJPDES Discharge Requirements

New Jersey surface water quality standards furnish ambient levels that provide for the protection of freshwater systems that may be used for recreational, domestic, potable, and/or agricultural uses. The NJPDES effluent limits are set to prevent exceedance of standards following discharge in and mixing with surface waters. To ensure that surface water discharges at Union Lake do not exceed ambient levels, the surface water quality standards are used as a conservative approach. These standards establish the design and operation goals for water treatment systems.

- o **National Historic Preservation Act**

This calls for a Stage IA survey to be performed during the design phase if a remedial action is taken. The Stage IA survey requires a literature search to identify areas of historical significance which should be protected during a remedial action. The Stage IA survey does not call for field surveys for areas of historical significance. The USEPA Region II was informed of this requirement by personnel from the USEPA's Environmental Impacts Branch (EIB).

- o **RCRA Regulations**

Soils and sediments with arsenic are considered a "RCRA Characteristic" hazardous waste (40 CFR 261.24, USEPA Hazardous Waste #0004), if the arsenic concentration levels in an extract produced by the EP Toxicity Test from a representative sediment sample exceed the EP Toxicity Test threshold level of 5.0 mg/l. Soils containing by-product salts from the production of monosodium methanoarsenate (MSMA) (RCRA listed waste K 031) and sediments contaminated by K 031 are considered a listed hazardous waste because they were derived from a listed waste (40 CFR 261.32).

MSMA by-product salt improperly stored on-site is believed to be the source of the arsenic contamination detected in sampling to date. Throughout this FS Report, ViChem arsenic-contaminated soils and sediments are considered a RCRA listed hazardous waste derived from the by-product salt waste, K 031. Arsenic is the listed hazardous constituent of concern for K 031 (see 40 CFR 261 Appendix VII). Guidance on this classification was received from USEPA Region II RCRA Branch and USEPA Headquarters Site Policy and Guidance Branch (SPGB) personnel.

- o **RCRA Land Disposal Restrictions (LDRs)**

RCRA LDRs were enacted to prohibit the disposal of untreated hazardous wastes in landfills, surface impoundments, injection wells and other forms of land disposal facilities. The LDRs establish Best Demonstrated Available Technology (BDAT) treatment standards for hazardous wastes prior to land disposal. RCRA characteristic wastes and RCRA listed hazardous wastes are subject to RCRA LDRs.

The RCRA characteristic wastes are part of the so-called "Third-Third" of RCRA wastes, which will be subject to LDR requirements after May 8, 1990. Proposed LDR standards for these wastes are not yet developed. The RCRA listed waste K 031 (by-product salts from the production of MSMA) is part of the "First-Third" of RCRA waste that is subject to the LDR "soft hammer" requirements as of August 1, 1988. The "soft hammer" provision limits disposal of K 031 wastes for which no treatment standard has been established. Until May 8, 1990, such waste may be placed in a landfill that meets minimum technology requirements (MTR) under two conditions: (1) the generator demonstrates and certifies to the USEPA that either no treatment technology is practically available; or (2) the waste has been treated to reduce meaningfully the long-term hazard of the waste when it is placed in the landfill. If the USEPA has not established a BDAT standard by May 8, 1990, land disposal of the listed waste is prohibited.

Delisting

As discussed above, the Union Lake sediments are a RCRA listed hazardous waste based on their derivation from K 031. According to RCRA SPGB, this waste could be declared nonhazardous and excluded from the protective management restraints of RCRA Subtitle C through a delisting procedure. In USEPA practice, a delisting exclusion on a "generator-specific" basis may be applied to waste already generated or anticipated for generation as part of an industrial process. In this CERCLA case, in comparison, arsenic-contaminated sediments are present on a Superfund site and will be treated and disposed of as part of the remedial action selected for the site.

Delisting can be done in three ways: (1) by a petition to the Administrator of USEPA; (2) by a rulemaking petition to the State of New Jersey, which was delegated delisting authority, 53 Federal Register 30054 (August 10, 1988); or (3) by a determination of the Regional Administrator of USEPA Region II in the ROD based on compliance with the delisting standards. A delisting petition submitted under 40 CFR 260.20, or the equivalent New Jersey regulation, allows any person to petition, to modify or to revoke any provisions of Parts 260 through 268, 124, 270 and 271 of Title 40 of the CFR - Code of Federal Regulations and 40 CFR 260.22, or the equivalent New Jersey regulations, which specifically provide generators the opportunity to exclude a waste on a "generator-specific" basis from the hazardous waste lists.

A petitioner must show that a waste generated at its facility does not meet any of the criteria under which the waste was listed (see 40 CFR 260.22 (a)). In addition, the Hazardous and Solid Waste Amendments (HSWA) require USEPA to consider factors, including additional constituents, other than those for which the waste was listed, if there is a reasonable basis to believe that such additional factors could cause the waste to be hazardous. Accordingly, a petitioner must demonstrate also that the waste does not exhibit any of the hazardous waste characteristics (i.e., ignitability, reactivity, corrosivity and EP Toxicity) and present sufficient information for the USEPA, or NJDEP, to determine whether the waste contains any other toxicants at hazardous levels (see 40 CFR 260.22, 42 U.S.C. 6921(f) and USEPA's background documents for the listed wastes). Although wastes that are "delisted" (i.e., excluded) have been evaluated to determine whether or not they exhibit any of the characteristics of hazardous waste, generators remain obligated to determine whether their waste remains nonhazardous based on the hazardous waste characteristics.

Delisting requires demonstrating that the material no longer exhibits the characteristic for which it was initially listed, and that no hazardous constituents of concern are present in the material. Factors considered for delisting include the nature of the waste, the concentration of the contaminant in the waste, the potential for contaminant migration, the quantity of the waste disposed, and the presence of other hazardous constituents potentially mixed in with the waste. Selection of the appropriate delisting procedure depends on the ultimate disposal selected for the treated waste, as discussed in the following section.

For off-site nonhazardous disposal, a petition followed by a public comment period would enable the Administrator of USEPA, or the State of New Jersey with equivalent regulations, to exclude a waste from regulation as a hazardous waste. On-site nonhazardous disposal permits the Regional Administrator to delist a waste in the ROD, with public comment on the ROD, but without all of the procedural steps of a formal rulemaking.

The USEPA and NJDEP generally utilize the VHS model for evaluating delisting petitions. The VHS model predicts groundwater contamination potential for wastes disposed of in a Subtitle D landfill. This environmental fate and transport model simulates contaminant transport through an aquifer that underlies a landfill. Under a landfill disposal scenario, the major exposure route of concern for hazardous constituents would be ingestion of contaminated groundwater. The VHS model reflects a reasonable worst-case disposal scenario that is appropriate when evaluating whether treated wastes could be disposed of as nonhazardous in a Subtitle D landfill. Details on the VHS model are given in 50 FR 7882 (February 26, 1985) and 50 FR 48896 (November 27, 1985).

Parameters of the VHS model include contaminant concentration in the leachate, penetration depth of leachate in the aquifer, distance from the disposal site to the compliance point, length of the disposal site, lateral dispersivity and vertical dispersivity. With the exception of the contaminant concentration in the leachate, determined by the EP Toxicity Test, and the length of the disposal site, dictated by the volume of waste, all of the values for the model's parameters were fixed by the USEPA. The VHS model outputs hypothetical hazardous constituent concentrations at a groundwater receptor 500 feet from the disposal site.

In the event that the treated waste is deemed appropriate for commercial use by the NJDEP, alternate exposure routes, such as air or surface water, are relevant for delisting. Therefore, in addition to the VHS model, a risk assessment, which has already been performed for the sediments, would be utilized to demonstrate that the treated waste represents an acceptable risk that the USEPA has determined is protective of human health and the environment.

Substantive Delisting Demonstration

In order to meet substantive delisting requirements, the EP Toxicity extract for total arsenic must be less than that computed for the VHS model. Utilizing 131,000 cubic yards as the total volume of contaminated sediments, the VHS model was used to "back-calculate" a maximum EP Toxicity concentration in the disposed waste, which would correspond to a receptor well concentration of 0.05 mg/l of arsenic, the MCL. MCLs are used by the delisting program as the levels of regulatory concern. If delisting is performed by the Regional Administrator, the ROD would need to solicit comment on the appropriateness of utilizing the VHS model to evaluate the waste.

For the lake sediments, the EP Toxicity extract must be less than 0.32 mg/l to meet a hypothetical "at the well" concentration of 0.05 mg/l. Based on the treatability studies, other information gathered during the RI, and with USEPA Region II concurrence, it is assumed that the treated material (fixated or extracted) will achieve an EP Toxicity extract concentration that will meet the level of regulatory concern, as predicted by the VHS model.

The EP Toxicity Tests conducted in the fixation treatability studies achieved an arsenic concentration in the extract of approximately 1 mg/l. At the time the tests were performed, the target delisting criterion was believed to be an EP Toxicity extract arsenic concentration of 5 mg/l, which the original treatability tests clearly achieved. Different formulations to optimize additive addition rates were not tried, nor were additional mixtures tried to determine the lowest arsenic concentration that could be achieved in the EP Toxicity extract, since the target concentration (less than 5 mg/l) was achieved.

The vendors who performed the fixation tests indicated that it would be feasible to achieve a leachate concentration lower than 1 mg/l total arsenic by increasing the amount of proprietary agent added to the fixation formulation (Falk and Gironda - Telephone Communication, 1988). As the sediment has a high organic content, the amount of powdered activated carbon added to the formulation would also be increased. Therefore, based on confirmation by the vendor, it is assumed, with USEPA Region II concurrence, that the contaminated sediment could be fixated to achieve an EP Toxicity concentration of less than 0.32 mg/l total arsenic. This would enable the fixated materials to meet substantive delisting requirements based on utilization of the VHS model to evaluate the waste.

It is also believed that the arsenic concentration in the separated coarse sands could be reduced, as a result of extraction, to levels complying with the VHS calculated delisting level. Extraction was evaluated in the bench-scale treatability studies to determine the feasibility of this technology to extract arsenic from the sediments. It was unclear from the tests whether the water wash simply separated the fine sediment containing arsenic from the coarse sediments that contain little arsenic, or whether the water actually solubilized the arsenic contained in the sediment. It is believed, based on the treatability study and other data collected during the RI, that the water wash separated the fine sediments that contained most of the arsenic from the coarse sediments. The elutriate solution, containing both fine sediments and water, contained a majority of the arsenic while the washed sediments contained very little arsenic (36 mg/kg). Therefore a water "extraction" is deemed feasible to separate the coarse from the fine sediments, which in effect substantially reduces the arsenic concentration in the coarse sediments. It is believed that these coarse sediments could meet the substantive delisting requirements and thus be disposed of by nonhazardous methods.

These hypotheses are further supported by the fact that all the EP Toxicity Tests conducted on <u>untreated</u> sediment achieved an extract of less than 0.32 mg/l total arsenic. For this FS, it is thus assumed that the treated sediments can meet the substantive delisting requirements and can be disposed of as nonhazardous materials. This assumption is made with USEPA Region II concurrence. However, in order to ensure that only nonhazardous wastes are removed from Subtitle C control, an extensive verification testing program would be conducted for the sediments. Due to the heterogeneous nature of contaminated sediments, it is not feasible to test in advance every variation of material that would require treatment. Therefore, during design, verification testing would be conducted along with bench- and pilot-scale testing on the optimized treatment systems. Verification testing would also be performed on representative batches treated during the remedial action. Representative testing would be done to ensure that all treated materials complied with the VHS-calculated delisting level.

The authority for delisting the treated waste would rest with USEPA Headquarters, the NJDEP, or the USEPA Region II Regional Administrator, depending on the location chosen for final disposal of the treated sediments. On-site disposal of the treated sediments would permit delisting by the Regional Administrator in the ROD based upon the treated waste meeting the delisting criteria. Off-site disposal of the treated sediment in New Jersey would require a delisting petition to be reviewed by the NJDEP. In the event that the treated sediments are disposed of in a state other than New Jersey or Georgia, delisting would be performed by the USEPA Administrator.

The USEPA permits "upfront delisting" i.e., delisting petitions granted prior to the generation of waste, which without upfront exclusions would unnecessarily be considered hazardous. With respect to this CERCLA action, the arsenic-contaminated sediment waste exists, but the intent to delist would be incorporated in the ROD.

Conditional delisting would be permitted based on a program of treatment, sampling and analysis of the treated sediments to demonstrate that they have been treated to levels that are nonhazardous. The actual delisting of the waste would occur after the waste was treated.

During final design, the chosen treatment process would be optimized to assure that the treated waste would meet the delisting requirements with a considerable degree of certainty. The treated sediments would meet the substantive delisting criteria established by the VHS model and also the more stringent cleanup level established in the risk assessment for this material. It should be noted that arsenic is the hazardous substance of concern in the listed waste K 031. The assurance that this treated material consistently achieves the substantive delisting level of the VHS model and the level in the risk assessment would be established from bench-scale studies conducted during the design phase. In addition, verification testing conducted throughout the remedial action would assure that the substantive standards of the delisting program are met and that only nonhazardous wastes are removed from Subtitle C control.

Management of Delisted Materials

After the treated sediments have met the delisting requirements, they would no longer fall under RCRA Subtitle C control and a method of final disposition would be determined. This method is dependent upon whether or not the material is classified as a waste. If a material is classified by the NJDEP as ID 27 waste, it would be disposed of in an on-site or off-site nonhazardous solid waste landfill. However, if a beneficial use can be identified, and if the sediments are treated to below the more stringent action level of 20 mg/kg of arsenic, the NJDEP may not consider the material a waste. For treated sediments designated by NJDEP as suitable for the commercial market, the potential exists for use as a construction aggregate. Material vendors in the region have expressed interest in acquiring the sandy sediments treated by both extraction and fixation for a number of construction applications. The treated sediment could also be used as "clean fill" to restore the excavated areas of the lake. These methods of final disposition of the treated sediments would be environmentally sound and would also result in substantially reduced costs compared to disposal in a nonhazardous waste Subtitle D landfill.

If, during final design, it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting agent would be required. Treatability tests indicated that sodium citrate would reduce the sediment arsenic concentration to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediments.

Subtitle C Landfill Disposal

If the treated sediments are not delistable, USEPA Headquarters SPGB personnel have provided guidance on the criteria to allow for their disposal in a hazardous waste RCRA Subtitle C landfill. Since no BDAT is presently available for K 031 listed hazardous waste, a "treatability variance" could be applied for if the treated sediments do not meet the 0.32 mg/l arsenic leachate concentration established through application of the VHS model. For the treated Union Lake sediments, this treatability variance is 1 mg/l arsenic concentration in an EP Toxicity Test, according to USEPA Headquarters SPGB personnel. Achieving this level would allow the treated sediments to be disposed of in a RCRA Subtitle C hazardous waste landfill.

If a BDAT standard for the listed waste K 031 is not established by May 8, 1990, and the treated sediments are not delistable, land disposal of the sediments would be prohibited. In contrast, once the waste meets the delisting criteria, the treated material is no longer subject to RCRA LDRs because the material is no longer a listed waste.

Summary

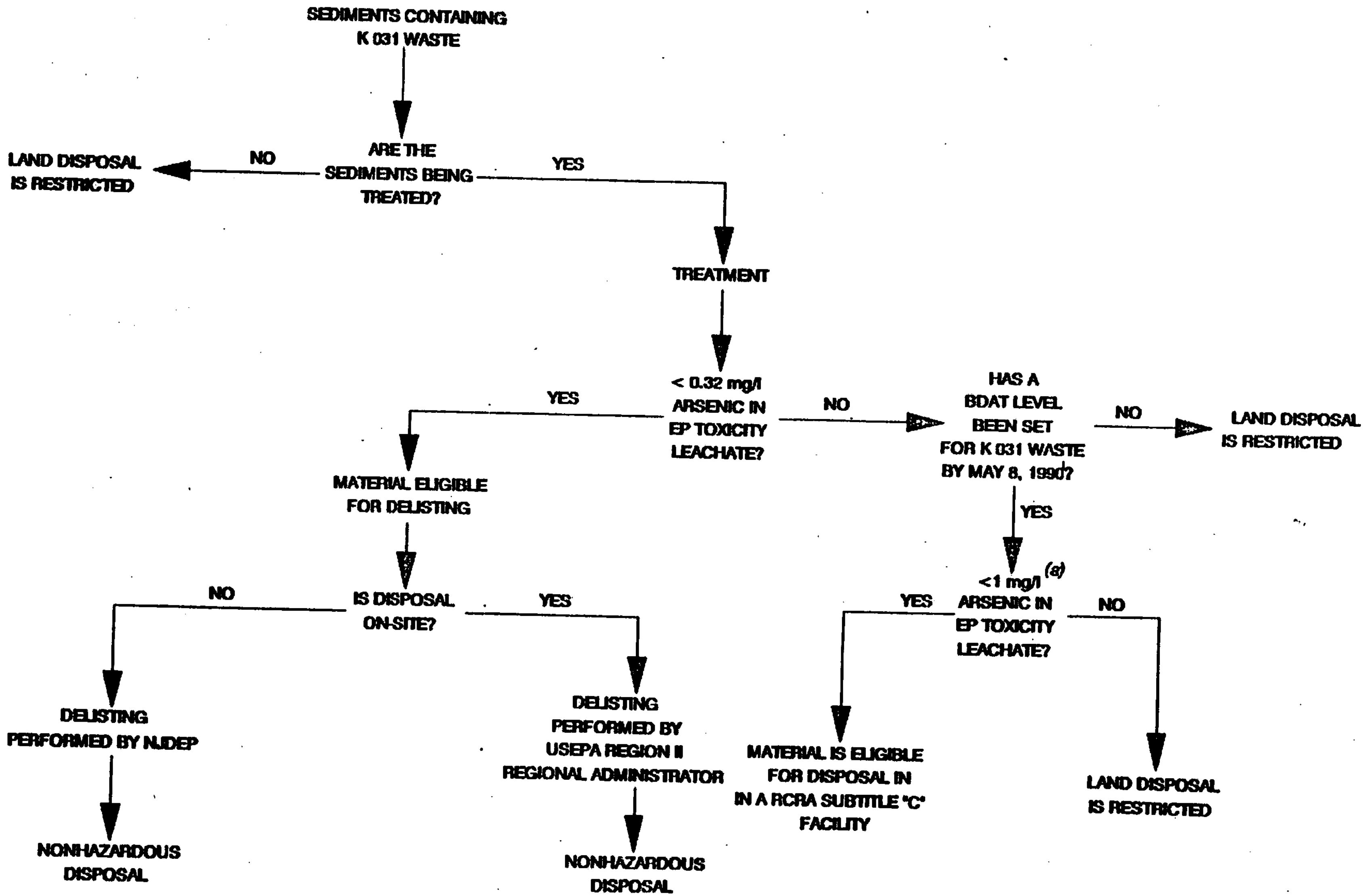
Figure 3-1 presents a flow chart showing the impact of RCRA LDRs on the Union Lake sediments. To summarize the discussion above, BDAT levels for the RCRA listed hazardous waste K 031 have not yet been established. The Union Lake sediments containing elevated arsenic concentrations are considered K 031 waste because the contamination was derived from K 031 wastes generated and improperly stored at the ViChem site.

If BDAT standards governing the disposal of the K 031 wastes are not established by May 8, 1990, these wastes cannot be disposed of on the land. However, since BDAT standards are not presently established, USEPA Headquarters SPGB personnel have given the following guidance to USEPA Region II regarding the disposal options for the treated lake sediments.

- If, after treatment, the sediments meet the substantive delisting requirement of 0.32 mg/l in the EP Toxicity extract, they can be delisted. This will remove the sediments from RCRA Subtitle C management control and is not contingent on there being a BDAT standard in effect at the time of remediation. Region II may utilize delisting in

FIGURE 3-1

RCRA DISPOSAL CONSIDERATIONS



(a) *THIS IS A "TREATABILITY VARIANCE" AND APPLIES REGARDLESS OF WHAT RE ESTABLISHED FOR THE K 031 WASTE*

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the ROD for the treated sediments for on-site nonhazardous disposal. A delisting petition to the Administrator of the USEPA or to the NJDEP would be required for off-site nonhazardous disposal. The delisted sediments could also potentially be reused for a beneficial purpose, based on a risk assessment and prior State approval.

- If, after treatment, the treated sediments do not comply with the VHS model criterion of 0.32 mg/l in the EP Toxicity extract, then they cannot be considered nonhazardous material. A treatability variance of 1 mg/l arsenic in the EP Toxicity leachate could be applied for. If the treated sediments can meet this level, but cannot meet the 0.32 mg/l criterion, then the treated sediments can be disposed of only as hazardous waste in a RCRA Subtitle C landfill. This option applies only if a BDAT standard is in effect (i.e., the "hard hammer" provisions are not in effect), and applies regardless of what the BDAT standards for wastes are.

- If, after treatment, the treated sediments do not comply with the 1 mg/l treatability variance EP Toxicity criterion, they cannot be disposed of in any type of landfill. An alternate remedial technology would have to be chosen that would achieve this minimum level, or a different remediation strategy would be required.

- If, after May 8, 1990, a BDAT standard for the listed waste K 031 has not been established, and the sediments fail to meet the delisting criterion allowing their removal from RCRA Subtitle C control, they cannot be land disposed.

Based on the treatability studies, information collected during the RI, and information supplied by vendors, it is assumed that both fixation and water wash extraction can be optimized and that the treated sediments from either process would meet the delisting requirements. Bench- or pilot-scale treatability studies to achieve optimized treatment systems would be performed as part of the design to verify this assumption. Extensive testing would also be required during the remedial action to verify that all possible sediment types are treated to delistable levels.

Assuming the treated sediments meet the delisting requirements, a determination of whether or not the material can be classified as ID 27 waste would have to be made to facilitate the means of final disposition. If the material is classified as ID 27 waste by the NJDEP, then the material may be disposed of in an on-site or off-site Subtitle D landfill. If the material is not classified as ID 27 waste, it may be used as clean fill for the excavated areas of the lake or introduced into the commercial market for use as a construction aggregate, substantially reducing remediation costs.

3.1.2 Combination of Applicable Technologies into Feasible Remedial Alternatives

An overview of the technology screening presented in Section 2.0 and Table 2-3 indicates that three basic remedial alternatives exist for the contaminated sediments:

1) No Action

2) Removal, Treatment and Disposal

3) Containment (RCRA Landfill)

The development of the remedial alternatives was based on the identification and screening of technology types and process options as discussed in Section 2.4. Regulatory requirements require that a no action alternative be developed in order to serve as a baseline against which the other alternatives can be compared. Thus Alternative 1 was developed. The screening performed in Section 2 identified the arsenic-contaminated sediment to be treatable utilizing sediment fixation or water extraction, with subsequent on-site or off-site disposal of the treated sediment. Alternatives 2A, 2B, 2C, 3A, 3B, 3C and 3D were developed considering these options. Off-site RCRA and on-site RCRA disposal options for the contaminated sediment passed the initial screening and are evaluated in Alternatives 4A and 4B, respectively. Alternative 5C is a containment alternative that evaluates covering the contaminated areas of Union Lake with a coarse sand layer.

Based on the requirements of the remedial action objective and associated feasible remedial technologies, the following combined remedial alternatives are thus identified:

Alternative 1 - No Action

Alternative 2A - Removal/Fixation/Off-Site Nonhazardous Landfill

Alternative 2B - Removal/Fixation/On-Site Nonhazardous Landfill

Alternative 2C - Removal/Fixation/Lake Deposition

Alternative 3A - Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Alternative 3B - Removal/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Alternative 3C - Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal

Alternative 3D - Removal/Extraction/Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal

Alternative 4A - Removal/Off-Site RCRA Landfill

Alternative 4B - Removal/On-Site RCRA Landfill

Alternative 5 - In Situ Sand Covering

3.1.3 Evaluation Criteria and Approach

The factors considered in the three evaluation criteria (i.e., effectiveness, implementability and cost) are discussed in the USEPA's March 1988 Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. A brief description of these factors is given below.

Effectiveness Evaluation

The effectiveness evaluation considers the capability of each remedial alternative to protect human health and the environment and to achieve the target cleanup concentrations. The target arsenic cleanup level for sediments is 20 mg/kg and 120 mg/kg in the more accessible areas and less accessible areas, respectively. In order to satisfy requirements for nonhazardous disposal of treated sediments, the treated product must have an EP Toxicity concentration of less than 0.32 mg/l arsenic. Each alternative is evaluated as to the protection it would provide, and the reductions in toxicity, mobility or volume it would achieve.

Implementability Evaluation

The implementability evaluation is used to measure both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative. In addition, the availability of the technologies involved in a remedial alternative is also considered.

Cost Evaluation

Costs may be used in the screening process to discriminate between treatment alternatives, but not between treatment and non-treatment alternatives.

Cost evaluation includes estimates of capital costs, annual operation and maintenance (O&M) cost, and present worth analysis. These conceptual cost estimates are order-of-magnitude estimates, and have been prepared based on:

- o Preliminary conceptual engineering for major construction components;

- Unit costs of capital investment and general annual operation and maintenance costs available from USEPA documents (USEPA 1985b and USEPA 1985c) and from Ebasco in-house files.

Present worth costs are used for comparisons among the remedial alternatives, and they are estimated based on a designated discount rate and system life. It should be noted that treatment and non-treatment alternatives (containment and no action) are not compared with respect to cost, as they inherently do not provide similar degrees of remediation.

As a result of the screening process, effectiveness, implementability and present worth costs are then used to compare the alternatives, especially alternatives that are very similar. As a result of this comparison, the least favorable remedial alternatives are ruled out from further consideration or detailed evaluation. The alternatives that pass this screening are taken into detailed evaluation in Section 4.0.

3.1.4 Other Considerations in the Development of Remedial Alternatives

The removal and treatment alternatives developed from the screening of technologies in Section 2.0 will be evaluated considering remediation to be conducted under two scenarios: 1) the lake is at its full condition, and 2) the lake is at drawdown. Presently, the lake has been lowered eight to nine feet to facilitate dam reconstruction. It is expected that construction will be complete by June of 1990. Because of the likely timing of remedial actions at the site, it is unlikely that any remedial action in the lake could be taken until after dam reconstruction is complete. Implementation of the remedial action could be conducted considering three scenarios:

1) The lake would be allowed to remain at drawdown until completion of the remedial action;

2) The lake would be filled at the completion of the dam reconstruction and then lowered for the implementation of the remedial action, and;

3) The lake would be filled and remediation conducted with the lake at its full condition.

If the lake remains at drawdown, it is believed that dry excavation techniques could be utilized to remove the contaminated sediments. Aerial photographs indicate that the northern end of the lake may potentially be a swamp-like area. If this is the case, low ground pressure backhoes may be required to remove the contaminated sediment.

If the lake is filled at the completion of the dam, dredging techniques would be utilized to remove the contaminated sediment.

If the lake is filled at the completion of the dam project and then lowered for implementation of the remedial action, it would be difficult to estimate the physical characteristics of the sediments (primarily the solids content). This would be dependent on the time period between drawdown and remediation, the weather during this period, and the elevation of the lake. Most likely a combination of dry excavation techniques and dredging techniques would be required.

In order to simplify the FS report and due to the uncertainties associated with anticipating the lake's condition at the time of remediation, the alternatives will be evaluated with either of two assumptions: (1) that the contaminated sediments would be completely submerged requiring hydraulic dredging or (2) that the contaminated sediments would be exposed facilitating dry excavation. Final design would determine the existing condition of the lake sediments and the most appropriate method of removal.

3.2 DESCRIPTION AND SCREENING OF REMEDIAL ALTERNATIVES

The purpose of this section is to describe and screen the remedial action alternatives developed in Subsection 3.1.2 to narrow the number of potential remedial alternatives for detailed analysis, while preserving a range of technical options. Screening criteria conform with remedy selection requirements set forth in CERCLA as amended, Section 121, and in the NCP (40 CFR 300.68 (g)).

3.2.1 Alternative 1 - No Action

Description: The no action alternative provides the baseline against which other responses can be compared. It would result in leaving the arsenic-contaminated sediments intact. The minimal action would consist of environmental monitoring and security measures. In addition, education programs would be implemented to inform the public about potential hazards.

A long-term monitoring program for Union Lake would include sediment sampling and lake water sampling. In addition, ecological surveys would be performed with the sampling. Site security measures would include posting warning signs and implementing institutional controls only. Fencing of an 870-acre lake would be ineffective and impractical. Because this alternative results in wastes remaining on-site, 1986 CERCLA amendments would require that the site be reviewed every five years.

Effectiveness: This alternative would reduce the potential for direct human contact (through the institutional controls of lake water uses); however, access restriction measures could be violated. This alternative would not achieve any reduction in the volume, toxicity or mobility of contaminants. It would not attain any ARARs since this response would not address the threat of the off-site migration of contaminants. Contaminants would remain in the lake and could possibly migrate downstream by leaching or through resuspension of particles into lake water.

Implementability: From a technical perspective, this alternative would be easy to implement (posting warning signs), but extensive site monitoring would require attention to long-term administrative feasibility considerations. Some administrative effort would also be required to obtain institutional controls. These institutional controls would include public education programs to heighten public awareness concerning the restricted use of the lake. Monitoring technologies are reliable and readily available.

Cost: No action would be the least expensive alternative under consideration. It is estimated that this alternative would require a capital cost of approximately $7,500 and an annual operation and maintenance cost of approximately $40,000 (per year for 30 years). The present worth cost based on a 5% discount rate after inflation is approximately $620,000.

Conclusion: The no action alternative will be retained for detailed evaluation as it serves primarily, but not always, as a baseline for comparison with other remedial alternatives. This alternative is critical in the development of a range of source control alternatives.

3.2.2 Alternative 2A - Removal/Fixation/Off-Site Nonhazardous Landfill

Description: Figure 3-2 depicts the contaminated areas presenting health risks in Union Lake. Hydraulic dredging was identified in the initial screening investigation as the only practicable method for removing contaminated sediments from the lake if remediation is conducted when the lake is at its full condition. A Mud Cat* hydraulic dredging unit or an equivalent would be used to dredge an average depth of 1.0 ft of sediment and to pump the dredged sediment to the fixation plant for subsequent treatment and disposal. The volume of contaminated sediments to be dredged is estimated to be 131,000 cubic yards. Figure 3-3 shows flow diagrams of all of the treatment systems. Figure 4-1 presents a schematic diagram of the treatment system.

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* In this report, any mention of the trade names of commercial products and processes does not constitute endorsement or recommendation for use.

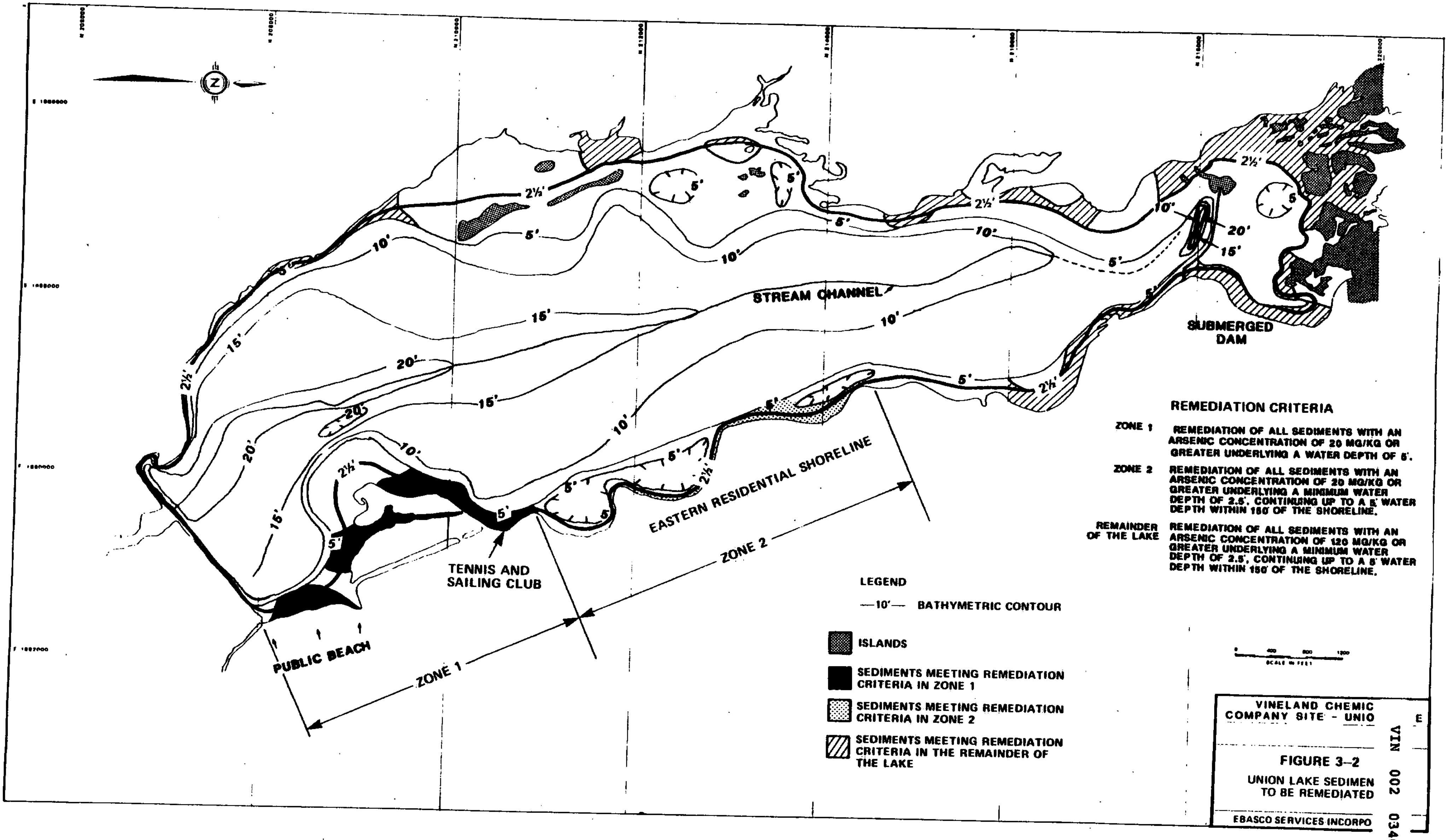

FIGURE 3–2
UNION LAKE SEDIMEN TO BE REMEDIATED

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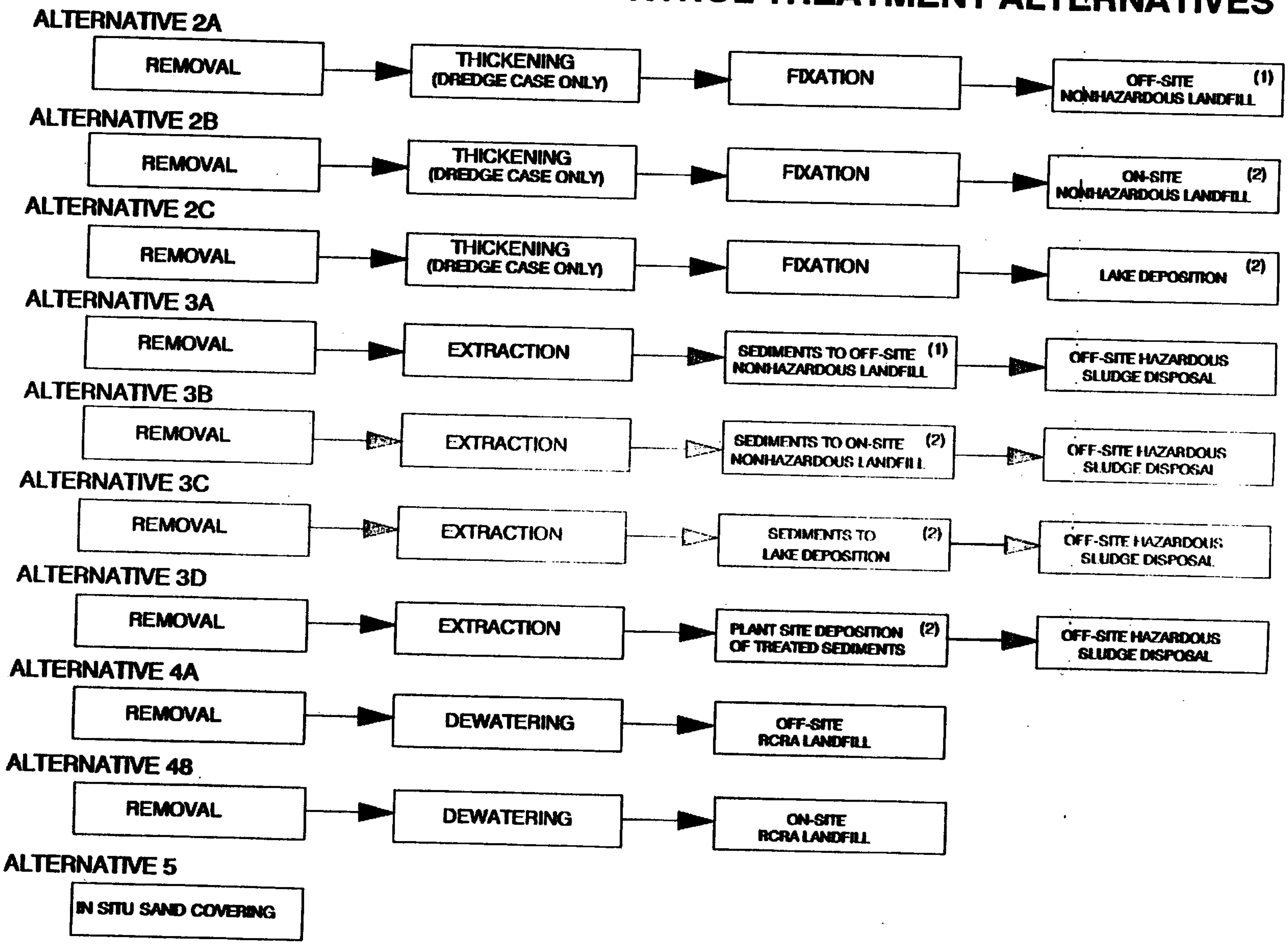
FIGURE 3-3
SCHEMATICS OF SOURCE CONTROL TREATMENT ALTERNATIVES



(1) TREATED MATERIALS REQUIRE DELISTING BY NJDEP

...ALS REQUIRE DELISTING BY EPA REGION II REGIONAL ADMINISTRATOR

VIN 002 0347

If remediation were conducted when the lake is at drawdown, dry excavation technologies and equipment would be utilized to remove the contaminated sediments. Some of the areas where contaminated sediments are to be removed may exhibit swamp like conditions necessitating the need for a low ground pressure backhoe. The volume of contaminated sediments to be excavated is 131,000 cubic yards.

A treatment plant for contaminated sediment fixation treatment would be constructed at the site. The hydraulically dredged sediment, which would contain approximately 20% solids, would be pumped to the thickeners to allow the separation of water and solids and thickening of the settled sediment. If remediation were conducted with the lake at drawdown, the excavated sediment would contain little water and therefore could be taken directly to a fixation unit, where it would be mixed with water and additives. Chemicals would be added to the contaminated sediment in the fixation unit to chemically stabilize/immobilize the arsenic. After curing for more than 48 hours, the fixated sediments would be trucked to a nearby nonhazardous landfill site for disposal. It is assumed that the fixated sediments would be delistable.

If dredging was required to remove the contaminated sediments, a treatment plant for supernatant treatment would also be constructed at the site. The supernatant resulting from the dredged sediments would be discharged from the thickeners to the clarifiers for removal of total suspended solids (TSS). Alum, ferric chloride and polymer would be added as coagulants in this clarification and precipitation process. After the removal of TSS and arsenic, the levels of other associated parameters such as iron would also be significantly reduced to a level no greater than that in the ambient water. The sludge would be combined with the sediment to be fixated. The treated effluent would be discharged to Union Lake.

The feasibility of the sediment fixation and supernatant treatment was evaluated during bench-scale studies as discussed in Section 7.0 of the Remedial Investigation (RI) report.

Reviews would be required every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative.

Effectiveness: Chemical fixation would achieve a permanent remedy for the dredged or excavated sediments by immobilizing arsenic contaminants and would minimize the potential for leachate generation. This alternative would achieve the target cleanup objective of 20 mg/kg in more accessible areas and 120 mg/kg in the less accessible areas. Removal, treatment and off-site disposal of these sediments would eliminate the source of health risk. However, sediments with arsenic concentrations greater than 20 mg/kg would remain in areas of the lake under more than 2.5 feet of water. The dynamics of the lake could redistribute contaminated sediments into clean remediated areas.

No adverse effects are anticipated with implementation of this remedial alternative. Trucks would be used for transporting the treated sediment to a nearby nonhazardous landfill site. Additional traffic would cause noise and air pollution and a possible increase in accidents in the surrounding areas of the site. These potential adverse impacts can be minimized by appropriate preventive measures, such as covering the wastes and decontaminating the trucks.

This remedial action would provide effective treatment and would adequately protect human health and the environment. The ARARs and appropriate criteria would be attained under this alternative.

Implementability: Chemical fixation is a well-developed and reliable technology. The chemical additives for fixation and immobilization are commercially available, and the process equipment can be assembled using conventional off-the-shelf hardware. The fixation system could be designed and constructed for specific use at the site.

It is assumed that the fixated material would be delistable and could be disposed of in a nonhazardous landfill facility as discussed in Subsection 3.1.1.2. Therefore the alternative would not trigger the LDRs.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $54,723,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $55,338,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $54,132,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $54,747,000.

Conclusion: Chemical fixation of wastes addresses the current statutory preference for permanent remedies designed to reduce the mobility of wastes. Sediments posing health risks would be treated and removed from the site. Thus this alternative is retained for detailed evaluation.

3.2.3 Alternative 2B - Removal/Fixation/On-Site Nonhazardous Landfill

Description: The operations involved in this alternative would be the same as those of Alternative 2A except that the fixated sediments would be disposed of at a newly constructed on-site nonhazardous landfill. In addition, reviews would be conducted every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative. Figure 3-3 shows a flow diagram of the treatment system. Figure 4-1 presents a schematic diagram of the treatment system.

As discussed in Alternative 2A, it is believed that the fixated waste would meet the delisting requirements and thus could be disposed of in a nonhazardous landfill, according to regulatory requirements. Delisting by the NJDEP would not be required since disposal is on-site. The USEPA's Regional Administrator could choose nonhazardous disposal based on the sediments meeting the delisting requirements. The on-site landfill would be constructed and operated according to the requirements specified in the New Jersey Solid and Hazardous Waste Management Regulations.

An interpretation of the term "on-site" given to USEPA Region II by USEPA Headquarters SPGB personnel states that a landfill would be considered "on-site" only if it was constructed at the ViChem plant site. A landfill constructed near Union Lake would be considered off-site. In this report an on-site landfill refers to one that would be constructed at the ViChem plant site itself.

Effectiveness: The same screening concerns about effectiveness with implementing Alternative 2A can be applied to this alternative, except that additional environmental and public health impacts may be associated with the construction of the on-site nonhazardous landfill.

The ViChem plant site is not a sensitive ecosystem area such as a wetlands area. On-site landfilling of treated sediments would pose little risk to groundwater and surface water qualities due to the low mobility of fixated sediments and the effectiveness of the landfill system. The long-term hazard from the failure of the landfill system is unlikely. Therefore there are no appreciable environmental impacts for this landfill site.

Implementability: The same implementability screening concerns discussed in Alternative 2A can be applied to this alternative. In addition, the constructibility and reliability concerns associated with the construction of an on-site nonhazardous landfill are applicable to this alternative. The construction techniques for capping systems, liner systems, drainage systems and leachate collection systems are conventional and relatively simple. As the ViChem site is a CERCLA site, the permitting requirements are waived. The land is assumed to be available, but it may not meet the local zoning regulatory requirements. Administrative efforts would be required to coordinate activities between state and local agencies.

It is assumed that the treated material could meet the delisting requirements and be disposed of in a nonhazardous landfill. Since the material would be considered nonhazardous, land disposal restrictions would not apply.

USEPA Headquarters SPGB informed USEPA Region II that since the landfill would be on-site, a delisting petition to USEPA Headquarters would not be necessary. The Region II Regional Administrator could choose this alternative based on information indicating that the treated sediments could meet the delisting requirements.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $43,153,000 and $228,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $46,658,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $42,562,000 and $228,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $46,067,000.

Conclusion: This alternative would provide the same permanence of remedy as Alternative 2A. On-site nonhazardous landfilling of the treated sediments is viable and enables this alternative to be retained for detailed evaluation.

3.2.4 Alternative 2C - Removal/Fixation/Lake Deposition

Description: The operations involved in this alternative would be the same as those of Alternative 2A except that the fixated sediments would be disposed of in Union Lake. Figure 3-2 shows a flow diagram of the treatment system. Figure 4-1 presents a schematic diagram of the treatment system.

The product of the sediment fixation is a physically stable solid with a rock-like appearance. The fixated product would be deposited in the previously dredged/excavated areas of Union Lake.

Long-term monitoring would be required to measure the effectiveness of this alternative.

Effectiveness: The same effectiveness concerns with implementing Alternative 2A can be applied to this alternative except that additional environmental impacts may be associated with the lake deposition of the fixated sediments. Fixation of the sediments would significantly reduce the mobility of the arsenic. The long-term hazard from the failure of the fixation process is unlikely. However, adverse impacts may occur to the habitats of biota, fish and wildlife.

Implementability: The same implementability concerns in Alternative 2A can be applied to this alternative. In addition, the concerns associated with lake deposition are included. Depositing the fixated sediments in previous areas of removal would be relatively simple. However, there is no direct and practical means of monitoring the effectiveness of the fixation once the material is deposited into the lake. Further, if it were determined that the fixation technology failed and the material leached appreciable amounts of arsenic, it would be very difficult to recover the material due to mixing of the sands and the fixated product.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $36,318,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $36,933,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $35,727,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation is $36,342,000.

Conclusion: Lake deposition of the fixated sediments is eliminated from further evaluation due to the inability to monitor the effectiveness of this alternative.

3.2.5 Alternative 3A - Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Description: Arsenic-contaminated sediments would either be hydraulically dredged or excavated depending on the condition of the lake at the time of remediation as discussed in Alternative 2A. Two-stage mechanical soil washing with water would be provided to remove arsenic from the sediments. The extracted sediments would be placed on trucks and transported to an off-site nonhazardous landfill. Clean fill would be brought on-site and deposited in the dredged/excavated areas. Reviews would be conducted every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative.

Extractant from the soil washing process would be treated in a system that would include the unit operations of chemical oxidation, coagulation, clarification and filtration.

It is estimated that 9,000 tons of arsenic-contaminated sludge would be generated. The arsenic-contaminated sludge would be transported to an off-site RCRA facility for treatment and disposal. Figure 3-2 shows a flow diagram of the treatment system. Figure 4-6 presents a schematic diagram of the treatment system.

Effectiveness: This alternative includes treating contaminated sediments with water in a reactor vessel. The process releases the small amounts of arsenic attached to coarse sands and also separates the fine organic matter with high concentrations of arsenic from the coarse sands. The effectiveness of this technology would depend on the extent to which arsenic is extracted from the sediments with the water. The treatability studies, using a single stage extraction, indicated that water would remove most of the arsenic from the overall sediment (2,780 mg/kg cleaned to 34 mg/kg after removing fines and/or desorbing arsenic). It is expected that a two-stage water wash would further reduce the sediment arsenic contamination. A pilot-scale test would be required to confirm the effectiveness of this technology.

The concentration of the extracted arsenic dissolved in the extractant would be reduced to below the MCL of 50 ug/l arsenic by chemical oxidation, coagulation/clarification and filtration. This process would also separate fine organics containing arsenic from the solution. Upon meeting MCLs, the extractant could be discharged to Union Lake.

This remedial alternative would attain the health-based cleanup target level by reducing the toxicity, mobility and volume of the contaminated sediments that were identified as a public health risk in the risk assessment. A long-term monitoring program would be required to measure the effectiveness of this alternative. There are no long-term adverse impacts on public health and the environment resulting from the implementation of this remediation.

Implementability: Sediment washing/extraction systems utilize available equipment from process industries, and the reliability is generally high from an operation and maintenance standpoint. Mobile type soil washing/extraction systems are currently commercially available. The USEPA operates a mobile sediment washing unit that is capable of processing 4 to 18 cubic yards of soil per hour depending on the sediment properties and the optimum period of reaction. Extraction systems are not complex and can be assembled using conventional off-the-shelf hardware. The system could be designed and constructed for specific use at the site.

Similarly, extractant treatment systems are conventional industrial extractant physical-chemical treatment processes which can be designed and constructed for specific uses utilizing conventional off-the-shelf hardware. These technologies are well developed and highly reliable.

It is expected that the extracted sediment would be delistable based on EP Toxicity Test results of untreated sediments and the VHS model as discussed in Section 3.0, and thus could be disposed of in a nonhazardous landfill facility. Since the material would be nonhazardous, land disposal restrictions would not apply. The extractant containing the fine sediments would be treated to MCL levels and would also meet the substantive delisting requirements. The arsenic-contaminated sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility and treated according to BDAT requirements. The sludge would ultimately be disposed of in a RCRA Subtitle C Landfill in accordance with the land ban. It is assumed that the EP Toxicity concentration of the treated sludge would comply with the 1 mg/l arsenic leachate treatability variance but not the 0.32 mg/l level that would allow for nonhazardous disposal of material.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $27,093,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $27,708,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $26,502,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $27,117,000.

Conclusion: Water extraction of arsenic provides permanent remedies to remove arsenic contamination from the sediments excavated from the lake. This alternative would reduce the toxicity and mobility of wastes and is retained for detailed evaluation.

3.2.6 Alternative 3B - Removal/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those of Alternative 3A except the processed sediments would be disposed of in an on-site nonhazardous landfill because the treated sediments would be expected to comply with the hazardous waste delisting criteria. The on-site landfill facility would be constructed as described in Alternative 2B. Figure 3-2 shows a flow diagram of the treatment system. Figure 4-6 presents a schematic diagram of the treatment system.

Effectiveness: Both the effectiveness of two-stage water extraction discussed in Alternative 3A and the effectiveness of an on-site nonhazardous landfill discussed in Alternative 2B are applicable for this alternative. The water extraction would significantly reduce the level of arsenic concentration in the sediment to meet the delisting criteria, so that the treated sediment could be safely deposited in an on-site nonhazardous landfill facility. The on-site nonhazardous landfill would not pose any appreciable environmental impacts to surface water, groundwater and the ecosystem at the site.

The extractant water would be treated utilizing conventional industrial waste water treatment units as discussed in Alternative 3A. Arsenic concentration in the extractant would be reduced to meet MCLs. The arsenic-contaminated sludge would be transported to a RCRA treatment and disposal facility.

Implementability: As discussed in Alternative 3A, mobile soil-washing/extraction systems are currently commercially available. A large-scale extraction system could be designed and constructed for specific use at the site. The extractant treatment systems are conventional waste water treatment processes and could be designed and constructed for site-specific applications.

The implementability of an on-site nonhazardous landfill facility discussed in Alternative 2B is applicable for this alternative. A long-term monitoring program would be required at the landfill site. Five-year reviews, involving standard sampling and surveying practices, would be required for the site as well.

As discussed in Alternative 3A, the clean sediments would be expected to meet the delisting requirements to enable disposal in a nonhazardous landfill. RCRA land disposal restrictions would therefore not apply to this material. An on-site nonhazardous landfill would be constructed on the ViChem property adjacent to the plant. As this is a CERCLA site, the permit requirements would be waived. The extractant treatment system would reduce the water arsenic concentration to levels below MCLs, enabling disposal to Union Lake. The arsenic-contaminated sludge would be transported to a RCRA treatment and disposal facility.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $22,063,000 and $228,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $25,568,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $21,472,000 and $228,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $24,977,000.

Conclusion: This alternative would provide the same permanent remedies as Alternative 3A, however it would require the construction of an on-site landfill and the implementation of a long-term monitoring program. This alternative is retained for further evaluation.

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3.2.7 Alternative 3C - Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those of Alternative 3A except the treated sediments would be disposed of in the previously dredged/excavated areas of Union Lake. A long-term management program would be required to measure the effectiveness of this alternative.

Due to the nature of the sediments in Union Lake, the product of the extraction process would be a clean, coarse sand. The sand would be transported by truck or barge to areas of remediation, deposited, and graded. Figure 3-2 shows a flow diagram of the treatment system. Figure 4-6 presents a schematic diagram of the treatment system.

Effectiveness: The effectiveness of two-stage water extraction as discussed in Alternative 3A is applicable for this alternative. Water extraction would significantly reduce the level of arsenic contamination in the sediment. Based on EP Toxicity Test results of untreated sediment and the results of the VHS model, previously discussed in Section 3.0, the treated sediment could meet the substantive delisting requirements and be safely deposited in the lake.

Lake deposition of the coarse sand may cause environmental impacts to the lake ecosystem. Adverse impacts may occur to the habitats of biota, fish and wildlife.

Implementability: As discussed in Alternative 3A, mobile soil washing/extraction systems are currently commercially available. Large-scale extraction systems could be designed and constructed for site-specific use. The extractant treatment system utilizes conventional industrial wastewater treatment processes that are well developed and highly reliable. The sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility.

As discussed previously, it is assumed that the extracted sediments would meet the delisting requirements and be classified as clean fill for deposition in the previously dredged/excavated areas of the lake. The NJDEP could waive an ID 27 waste classification of the treated sediments to allow their use as clean fill. A substantive requirement for classification as non-ID 27 waste is a reduction in the sediment arsenic concentration to 20 mg/kg, the more stringent action level in the lake. If, during final design, it is discovered that a two-stage water waste would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting medium would be required. Treatability tests indicated that sodium citrate would reduce the sediment arsenic concentration to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediments. The material would blend well in the environment since treatment would not drastically alter its form.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $18,263,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $18,878,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $17,672,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $18,287,000.

Conclusion: This alternative would provide a permanent remedy for removing arsenic contamination from the sediments identified as a public risk in the risk assessment. Lake deposition of the treated sediments would provide an economical means of disposal and eliminate the cost of clean fill for the dredged/excavated areas. Therefore this alternative is retained for further evaluation.

3.2.8 Alternative 3D - Removal/Extraction/Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those in Alternative 3A except the treated sediments would be disposed of on the ViChem plant site. Clean fill would be deposited in the areas of remediation. A long-term management program would be required to measure the effectiveness of this alternative.

The product of the extraction process would be a clean sand. The sand would be transported by truck to the plant site, deposited and graded. A one-foot layer of topsoil would be brought on-site to provide natural cover for the treated sediments. Figure 3-2 shows a flow diagram of the treatment system. Figure 4-6 presents a schematic diagram of the treatment system.

Effectiveness: The effectiveness of two-stage water extraction as discussed in Alternative 3A, is applicable for this alternative. Water extraction would sufficiently reduce the level of arsenic contamination in the sediments, enabling an EP Toxicity extract from the treated sediments to meet the substantive delisting levels established by the VHS model. The sediments could be safely deposited on the plant site with few adverse environmental impacts.

Implementability: As discussed in Alternative 3A, mobile soil washing/extraction systems are currently available. The extractant treatment system utilizes conventional industrial waste water treatment processes that are well developed and highly reliable. The sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility.

As discussed in Alternative 3C, the prerequisite to deposition is a classification of the treated material by NJDEP as non-ID 27 waste. A substantive requirement for this classification would be a reduction in the sediment arsenic concentration to 20 mg/kg, the more stringent action level in the lake and the plant site action level for soils. If, during final design, it is discovered that a two-stage water extraction will not sufficiently reduce the sediment arsenic concentration to below 20 mg/kg, sodium citrate could be used as an alternate extracting medium. Treatability studies indicated that sodium citrate would extract arsenic from the sediment to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the sediments.

Cost: If the remediation is conducted when the lake is at its full condition, the capital cost and annual operation and maintenance cost are estimated at $18,618,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $19,233,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation cost are estimated at $18,027,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $18,642,000.

Conclusion: This alternative would provide a permanent remedy for removing arsenic contamination from the sediments identified as a public risk in the risk assessment. Therefore this alternative is retained for further evaluation.

3.2.9 Alternative 4A - Removal/Off-Site RCRA Landfill

Description: The tasks of sediment dredging and thickening (via the removal of dredged supernatant water) or the excavation of dry sediments involved in this alternative would be the same as those described in Alternative 2A, except the settled sediment from dredging would be withdrawn from the sediment thickeners to a vacuum filter for further dewatering. The dewatered sediment would contain approximately 30 to 35% solids that would be suitable for landfill deposition.

If necessary, the dewatered dredged sediment or the excavated sediment would be stabilized by mixing it with an inert additive such as kiln dust. The supernatant from the thickening system and vacuum filters would be treated utilizing the clarification and precipitation process units described in Alternative 2A. Figure 3-2 shows a flow diagram of the treatment system.

Off-site RCRA landfilling would include transporting the arsenic contaminated sediment in sealed containers to a commercial RCRA hazardous landfill site.

Effectiveness: This alternative would consist of hydraulic dredging, dewatering, transporting and landfilling the sediments with treatment and discharge of the supernatant. The on-site dredging and dewatering operations would include removal of the source material with their subsequent consolidation into containers for off-site transport. If remediation of the lake was conducted during drawdown the alternative would consist of excavation, transporting and landfilling the sediments. The excavation operation would include removal of the source material with their subsequent consolidation into containers for off-site transport. A permitted RCRA disposal facility with the capacity and capability to handle this source material must be identified.

This alternative would eliminate the on-site release from source material and would eliminate contaminant exposure to humans and animals. The inherent dynamics of the lake could redistribute contaminated sediments from deeper areas of the lake to the shallow areas after remediation. Long-term monitoring and sediment transport modeling could be used to directly and indirectly measure the predominant dynamic forces within the lake.

This alternative would be effective at eliminating waste sources, leachate generation and contaminant migration from the removed sediments. Long-term monitoring would be required to monitor redistribution patterns of the sediments.

This alternative would attain the health-based cleanup target level of 20 mg/kg arsenic in the more accessible areas and 120 mg/kg in the less accessible areas, and would achieve a reduction in toxicity, mobility and volume of contaminants in the lake. However, it would not reduce the toxicity and volume of contaminated sediments in the environment overall. The off-site RCRA landfill would reduce the mobility of the arsenic contaminants by containment. If the landfill should fail, the contaminants could be re-released into the environment. In addition, the RCRA land disposal restrictions regulation (51 CFR 40572, November 7, 1988) would require that contaminated sediments be treated via the Best Demonstrated Available Technology (BDAT) prior to being placed in an off-site RCRA facility. ARARs pertaining to land disposal restrictions would not be attained since the wastes would not be treated by the BDAT.

Implementability: This remedial alternative has been demonstrated at many small hazardous waste sites. There should be no special difficulties in removing and transporting the sediment and in restoring the site. The major obstacles to implementing the alternative are identifying the disposal facilities capable of accepting the large volume of waste material and the associated cost of transport and disposal (i.e., RCRA landfill availability and capacity).

Implementation of this alternative would require an administrative effort to secure an off-site RCRA landfill for disposal. With the implementation of the RCRA land ban, this may be very difficult. Land disposal restriction regulations and DOT regulations for waste shipment would need to be met. Annual monitoring and five-year reviews would require additional administrative attention.

Off-site disposal of sediment from contaminated areas is a feasible option if an acceptable facility can be identified. The only currently recognized permanent land disposal facility is a double lined landfill. There are very few commercial facilities with double liners in the eastern United States capable of receiving the large volume of wastes that would be removed from the site. Implementation of this alternative would depend on the available capacity and the current laws that would prevail at the time of remediation.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $59,458,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $60,073,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $58,867,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $59,482,000.

Conclusion: The off-site disposal of contaminated soils without any treatment would not meet the land disposal restriction requirements. This alternative is therefore not feasible at this site.

3.2.10 Alternative 4B - Removal/On-Site RCRA Landfill

Description: The operations involved in this alternative would be the same as those of Alternative 4A, except that the dredged and dewatered sediments or excavated sediments would be disposed of at a newly constructed on-site RCRA landfill. A new RCRA Subtitle C containment facility could be constructed at the ViChem plant site. As discussed previously, this potential landfill area is considered to be within the site boundaries.

The RCRA landfill would have to be designed to include a double liner system, two leachate detection, collection and removal systems, and a groundwater monitoring program, according to applicable RCRA requirements. Figure 3-2 shows a flow diagram of the treatment system.

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Effectiveness: Even though the landfilling of hazardous waste was widely used as a management practice for years, it is now being discouraged by the USEPA, which makes obtaining approval for construction of a new facility very difficult. The on-site RCRA landfill alternative would remove hazardous wastes from the area of contamination into another area within the Superfund site boundaries. This on-site landfill would constitute RCRA land disposal, thus the land disposal restriction requirements would be applicable for this alternative. As discussed in Alternative 4A, ARARs pertaining to land disposal restrictions would not be attained since wastes would not be treated prior to being placed in a RCRA facility.

The RCRA landfill would provide only a long-term containment for the hazardous waste, but would not attain permanent remedy designed to reduce the toxicity, mobility and volume of wastes.

Removing contamination from Union Lake would reduce the risks to recreational users of the lake, contaminated leachate generation, and contaminant migration from sediments to lake water. The on-site RCRA landfill would not pose any appreciable environmental impacts to surface water, groundwater and the ecosystem around the landfill site. A long-term operation and maintenance/ management plan, including periodic groundwater monitoring, would be required for the post-closure activities.

Implementability: The RCRA landfill facility could be designed to satisfy all the applicable requirements. The potential landfill site would not be within the 100-year floodplain. The construction of a landfill facility is a conventional and proven technology and would be commercially available. The possibility of failure of a new RCRA landfill system would be relatively low. The land is assumed to be available; however, local zoning regulatory requirements may not be met.

Landfilling hazardous wastes without any treatment, in the immediate vicinity of an important water resource, is unlikely to be acceptable. The permitting process requires extensive investigations and acceptance by regulatory agencies. Important factors affecting the regulatory acceptance would be the site conditions, design, construction, operation, public uneasiness, closure, and post-closure monitoring. Additional attention would have to be redirected towards performing annual monitoring and implementing five-year review programs.

Cost: If the remediation is conducted when the lake is at full condition, the capital cost and annual operation and maintenance cost are estimated at $17,848,000 and $298,400 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $22,435,000.

If the remediation is conducted when the lake is at drawdown, the capital cost and annual operation and maintenance cost are estimated at $17,257,000 and $298,400 (per year for 30 years), respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $21,844,000.

Conclusion: This alternative would not meet the land disposal restriction requirements and would not provide a permanent remedy. Therefore it is eliminated from further evaluation for the site.

3.2.11 Alternative 5 - In Situ Sand Covering

Description: This remedial alternative would involve the covering of contaminated sediments within Union Lake with a layer of coarse sand. Coarse sand would be transported to the site by trucks, and either transferred to barges equipped with pneumatic pumps for dry solids or dumped from the trucks and graded. Coarse sand would be uniformly spread at predetermined areas to form a one-foot-thick layer atop those selected contaminated sediments. It is estimated that approximately 131,000 cubic yards of coarse sand would be required to cover approximately 81 acres of contaminated sediment with a one-foot depth.

Effectiveness: A one-foot sand covering atop those selected contaminated sediments would temporarily reduce the potential threats to public health via direct contact and ingestion of the contaminated sediments. Thus this alternative would reduce the risks via the sediment exposure pathways.

The covering of sediments that exceed the action level in shallow water would not reduce any toxicity or volume of the contamination sources, and may slightly reduce the physical mobility of the sources. This remedial alternative would not achieve the target cleanup level established for the lake sediments. Sand covering would not eliminate leaching and the migration of arsenic from the sediments to the lake water. The covering would, however, tend to minimize the physical migration or movement of the sediments. In addition, covering a portion of the lake shoreline with a one-foot sand cover may have an environmental impact on the lake ecosystem. Adverse impacts may occur to the habitats of biota, fish and wildlife.

A one-foot blanket of coarse sand on top of the contaminated sediments within the areas of remediation may not be permanent due to natural dynamic water movement, human disturbance during swimming, jogging, children digging in the sand, growth of vegetation, or wind-induced erosion during low water periods. These potential mechanisms for erosion and cover disturbance would therefore require a long-term monitoring and maintenance program.

Implementability: Coarse sand is a common construction material readily available locally. Trucks, front-end loaders, and/or pneumatic pumping for the sand layer installation are conventional techniques and are relatively simple to implement. The constructibility of this alternative is very high, while the reliability is low. The construction time is estimated at approximately six months. Annual monitoring would be required for the useful public life of the lake to ensure that the one-foot sand layer is maintained in those predetermined areas, and that contaminants or sediments are not migrating into new areas. This alternative would not trigger RCRA LDR requirements, as sediments from the lake would not be removed, treated, or disposed of.

Cost: The capital cost and annual operation and maintenance costs for the lake when it is full or at drawdown are estimated at $2,620,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a 5% discount rate after inflation, is $3,235,000.

Conclusion: Although this alternative does not achieve any reduction in toxicity or volume of the contaminated sediments, it may slightly reduce the mobility of contaminants. The alternative may not provide a permanent solution for the problems identified. However, in the event that the sediments cannot be treated to levels below those established by the treatability variance, this alternative would provide a relatively low-cost remedial action that would minimize contact with contaminated sediments. In situ sand covering is retained for further evaluation.

3.3 SUMMARY OF INITIAL SCREENING OF REMEDIAL ALTERNATIVES

Tables 3-1 and 3-2 present a summary of the conceptual costs and the alternative screening processes that were presented in Section 3.2. Conclusions from these tables are given below.

1) Extraction of arsenic contaminants from the sediments would reduce the volume, toxicity and mobility of contaminants, whereas fixation would only offer a reduction of mobility.

2) RCRA landfilling of the arsenic wastes (untreated sediments) would not provide a permanent remedy. Since no reduction in toxicity, mobility or volume would be achieved, Alternatives 4A and 4B are eliminated from detailed evaluation.

3) Off-site nonhazardous landfilling of the treated sediment may be more implementable than on-site landfilling due to state and community approval required for construction of a landfill. However, a cost savings is realized in utilizing an on-site landfill for disposal.

TABLE 3-1

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars Unit Cost	Capital Cost	Annual O/M Cost
1. Alternative 1 - No Action	1. Warning Signs	75	$100	$ 7,500	
	2. Quarterly Monitoring	40	$1,000		$40,000/yr
			Total	$ 7,500	$40,000/yr
2. Alternative 2A - Removal/Fixation/Off-Site Nonhazardous Landfill	1A. Hydraulic Dredging	354,000 cy	$ 6.5/cy	$ 2,301,000	
	1B. Excavation	131,000 cy	$13.30/cy	$ 1,742,300	
	2. Gravity Thickening	7×10^7 gal	$ 0.05/1,000 gal	$ 3,500	
	3. Supernatant Water Treatment	56×10^6 gal	$ 0.5/1,000 gal	$ 28,400	
	4. Chemical Fixation	167,000 cy	$ 200/cy	$33,400,000	
	5. Off-Site Transport	211,000 tons	$ 40/ton	$ 8,440,000	
	6. Off-Site Nonhazardous Landfill	211,000 tons	$ 50/ton	$10,550,000	
	7. Quarterly Monitoring				$40,000/yr
			* Total A	$54,723,000	$40,000/yr
			** Total B	$54,132,000	
3. Alternative 2B - Removal/Fixation/On-Site Nonhazardous Landfill	1A. Hydraulic Dredging	354,000 cy	$ 6.5/cy	$ 2,301,000	
	1B. Excavation	131,000 cy	$13.30/cy	$ 1,742,300	
	2. Gravity Thickening	7×10^7 gal	$ 0.05/1,000 gal	$ 3,500	
	3. Supernatant Water Treatment	56×10^6 gal	$ 0.5/1,000 gal	$ 28,400	
	4. Chemical Fixation	167,000 cy	$ 200/cy	$38,400,000	
	5. On-Site Nonhazardous Landfill	117,000 cy	$ 60/cy	$ 7,020,000	$180,000/yr
	6. Land	8 Acres	$50,000/acre	$ 400,000	
	7. Post Landfill Monitoring	16	$500		$ 8,000/yr
	8. Quarterly Monitoring				$ 40,000/yr
			Total A	$43,153,000	$228,000/yr
			Total B	$42,562,000	

* Total A Conceptual cost estimation considering remediation would be performed with the lake at its full condition, necessitating utilization of hydraulic dredging.

** Total B Conceptual cost estimation considering the remediation would be performed when the lake is at drawdown, allowing dry excavation techniques to be utilized. The remedial components, gravity thickening and supernatant water treatment would not be required if dry excavation were performed.

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TABLE 3-1 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars Unit Cost	1988 Dollars Capital Cost	1988 Dollars Annual O/M Cost
4. Alternative 2C – Removal/Fixation/Lake Deposition	1A. Hydraulic Dredging	354,000 cy	$ 6.5/cy	$ 2,301,500	
	1B. Excavation	131,000 cy	$13.30/cy	$ 1,742,300	
	2. Gravity Thickening	7 x 10^7 gal	$0.05/1,000 gal	$ 3,500	
	3. Supernatant Water Treatment	56 x 10^6 gal	$0.05/1,000 gal	$ 28,400	
	4. Chemical Fixation	167,000 cy	$ 200/cy	$33,400,000	
	5. Lake Deposition	117,000 cy	$ 5/cy	$ 585,000	
	6. Quarterly Monitoring				$40,000/yr
			Total A	$36,318,000	$40,000/yr
			Total B	$35,727,000	
5. Alternative 3A – Removal/ Extraction/Sediments to Off-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal	1A. Hydraulic Dredging	354,000 cy	$ 6.5/cy	$ 2,301,000	
	1B. Excavation	131,000 cy	$13.30/cy	$ 1,742,300	
	2. Gravity Thickening	7 x 10^7 gal	$ 0.05/1,000 gal	$ 3,500	
	3. Supernatant Water Treatment	56 x 10^6 gal	$ 0.5/1,000 gal	$ 28,400	
	4. Extraction	167,000 cy	$ 80/cy	$13,360,000	
	5. Extractant Treatment	15 x 10^6 gal	$ 4/1,000 gal	$ 60,000	
	6. Off-Site Transport	106,000 ton	$ 40/ton	$ 4,240,000	
	7. Off-Site Nonhazardous Landfill	106,000 ton	$ 50/ton	$ 5,300,000	
	8. Sludge Disposal	9,000 ton	$ 200/ton	$ 1,800,000	
	9. Quarterly Monitoring				$40,000/yr
			Total A	$27,093,000	$40,000/yr
			Total B	$26,502,000	
6. Alternative 3B – Removal/ Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal	1A. Hydraulic Dredging	354,000 cy	$ 6.5/cy	$ 2,301,000	
	1B. Excavation	131,000 cy	$13.30/cy	$ 1,742,300	
	2. Gravity Thickening	7 x 10^7 gal	$ 0.05/1,000 gal	$ 3,500	
	3. Supernatant Water Treatment	56 x 10^6 gal	$ 0.5/1,000 gal	$ 28,400	
	4. Extraction	167,000 cy	$ 80/cy	$ 3,360,000	
	5. Extractant Treatment	15 x 10^6 gal	$ 4/1,000 gal	$ 60,000	
	6. On-Site Nonhazardous Landfill	71,000 cy	$ 60/cy	$ 4,260,000	$180,000/yr
	7. Land	5 acres	$ 50,000/acre	$ 250,000	
	8. Post Landfill Monitoring	16	$ 500		$ 8,000/yr
	9. Sludge Disposal	9,000 ton	$ 200/ton	$ 1,800,000	
	10. Quarterly Monitoring				$ 40,000/yr
			Total A	$22,063,000	$228,000/yr
			Total B	$21,472,000	

TABLE 3-1 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars Unit Cost	1988 Dollars Capital Cost	1988 Dollars Annual O/M Cost
7. Alternative 3C - Removal/Extraction/ Lake Deposition of Sediments/ Off-Site Hazardous Sludge Disposal	1A. Hydraulic Dredging	354,000 cy	\$ 6.5/cy	\$ 2,301,000	
	1B. Extraction	131,000 cy	\$13.30/cy	\$ 1,742,300	
	2. Gravity Thickening	7 x 10^7 gal	\$ 0.05/1,000 gal	\$ 3,500	
	3. Water Treatment	56 x 10^6 gal	\$ 0.5/1,000 gal	\$ 28,400	
	4. Supernatant Extraction	167,000 cy	\$ 80/cy	\$13,360,000	
	5. Extractant Treatment	15 x 10^6 gal	\$ 4/1,000 gal	\$ 60,000	
	6. Lake Deposition	71,000 cy	\$ 10/cy	\$ 710,000	
	7. Sludge Disposal	9,000 ton	\$ 200/ton	\$ 1,800,000	
	8. Quarterly Monitoring				\$40,000/yr
			Total A	\$18,263,000	\$40,000/yr
			Total B	\$17,672,000	
8. Alternative 3D - Removal/Extraction/ Plant Site Deposition of Sediment/ Off-Site Hazardous Sludge Disposal	1A. Hydraulic Dredging	354,000 cy	\$ 6.5/cy	\$ 2,301,000	
	1B. Extraction	131,000 cy	\$13.30/cy	\$ 1,742,300	
	2. Gravity Thickening	7 x 10^7 gal	\$ 0.05/1,000 gal	\$ 3,500	
	3. Water Treatment	56 x 10^6 gal	\$ 0.5/1,000 gal	\$ 28,400	
	4. Supernatant Extraction	167,000 cy	\$ 80/cy	\$13,360,000	
	5. Extractant Treatment	15 x 10^6 gal	\$ 4/1,000 gal	\$ 60,000	
	6. Plant Site Deposition	71,000 cy	\$ 15/cy	\$ 1,065,000	
	7. Sludge Disposal	9,000 ton	\$ 200/ton	\$ 1,800,000	
	8. Quarterly Monitoring				\$40,000/yr
9. Alternative 4A - Removal/ Off-Site RCRA Landfill	1A. Hydraulic Dredging	354,000 cy	\$ 6.5/cy	\$ 2,301,000	
	1B. Excavation	131,000 cy	\$13.30/cy	\$ 1,742,300	
	2. Gravity Thickening	7 x 10^7 gal	\$ 0.05/1,000 gal	\$ 3,500	
	3. Supernatant Water Treatment	56 x 10^6 gal	\$ 0.5/1,000 gal	\$ 28,400	
	4. Dewatering System (Vacuum Filters)	131,000 cy	\$ 10/cy	\$ 1,310,000	
	5. Blending/Storage	131,000 cy	\$ 5/cy	\$ 655,000	
	6. Off-Site Transportation	197,000 tons	\$ 80/ton	\$15,760,000	
	7. Off-Site RCRA Landfill	197,000 tons	\$ 200/ton	\$39,400,000	
	8. Quarterly Monitoring				\$ 40,000/yr
			Total A	\$59,458,000	\$ 40,000/yr
			Total B	\$58,867,000	

TABLE 3-1 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars Unit Cost	Capital Cost	Annual O/M Cost
10. Alternative 4B - Removal/ On-Site RCRA Landfill	1a. Hydraulic Dredging	354,000 cy	$ 6.5/cy	$ 2,301,000	
	2. Gravity Thickening	7 x 10^7 gal	$ 0.05/1,000 gal	$ 3,500	
	3. Supernatant Water Treatment	56 x 10^7 gal	$ 0.5/1,000 gal	$ 28,400	
	4. Dewatering System (Vacuum Filters)	131,000 cy	$ 10/cy	$ 1,310,000	
	5. Blending/Storage	131,000 cy	$ 5/cy	$ 655,000	
	6. On-Site RCRA Landfill	131,000 cy	$ 100/cy	$13,100,000	$250,400/yr
	7. Land	9 acres	$ 50,000/acre	$ 450,000	
	8. Post Landfill Monitoring	16	$ 500		$ 8,000/yr
	9. Quarterly Monitoring				$ 40,000/yr
			Total A	$17,848,000	$298,400/yr
			Total B	$17,257,000	
	1B. Excavation	131,000 cy	$13.30/cy	$ 1,742,300	
11. Alternative 5 - In Situ Sand Covering	1. Coarse Sand Cover Installation	131,000 cy	$ 20/cy	$ 2,620,000	
	2. Quarterly Monitoring	40	$ 1,000		$ 40,000/yr
			Total	$ 2,620,000	$ 40,000/yr

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TABLE 3-2

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989) Capital	Annual O/M	Present Worth	Effectiveness	Implementability	Detailed Evaluation
NO ACTION						
Alt. 1 - No Action				1. Minimize access to contaminated sediment source areas by signs and public education 2. Does not attain ARARs 3. No reduction in toxicity, mobility or volume	1. Easy implementation 2. Monitoring technologies are reliable and available 3. State approval and community acceptance are questionable	Retained
o Lake at its Full Condition	0.003	0.04	0.62			
o Lake at its Drawdown Condition	N/A	N/A	N/A			
TREATMENT						
Alt. 2A - Removal/ Fixation/Off-Site Nonhazardous Landfill				1. Achieves permanence of remedy in those sediments identified as a public health threat 2. Reduces mobility of contaminants 3. Treated material is believed to be delistable 4. Short-term potential public health and environmental impacts due to handling and transportation 5. Facilitates lake restoration for public use 6. Does not attain all ARARs 7. Long-term adverse impacts could occur if significant redistribution of the contaminated sediments occurs 8. Requires pilot-scale study to confirm effectiveness	1. Chemical fixation is well developed and reliable technology 2. Full-scale operation of fixation is commercially available 3. Treatability studies proved fixation is a feasible technology 4. Potential impacts on public health and environment can be minimized by providing health/safety protection measures 5. Off-Site nonhazardous landfill facilities are commercially available 6. Long-term post-implementation management is required to measure effectiveness of this alternative 7. Delisting required	Retained
o Lake at its Full Condition	54.72	0.04	55.34			
o Lake at its Drawdown Condition	54.13	0.04	54.75			
Alt. 2B - Removal/ Fixation/On-Site Nonhazardous Landfill				1. Same as Items, 1, 2, 3, 5,6,7 and 8 in Alt. 2A 2. Long-term environmental impacts due to on-site landfill would be possible 3. Transportation impacts would be minimized	1. Same as Items 1,2,3,4, and 6 in Alt. 2A 2. Nonhazardous landfill technology is conventional and available 3. State approval and community acceptance of on-site nonhazardous landfill is required 4. Delisting preformed by USEPA Region II	Retained
o Lake at its Full Condition	43.15	0.228	46.66			
o Lake at its Drawdown Condition	42.56	0.228	46.07			

TABLE 3-2 (Cont'd)

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989) Capital	Annual O/M	Present Worth	Effectiveness	Implementability	Detailed Evaluation
Alt. 2C - Removal/Fixation/ Lake Deposition				1. Same as Items 2,3,5,6 and 8 in Alt. 2A 2. Long-term environmental impacts on the lake possible if fixation process fails 3. Minimizes transportation through populated areas	1. Same as Items 1, 2, and 3 in Alt. 2A 2. Transportation by barge is conventional and readily available 3. Long-term post implementation management is required 4. Impossible to monitor effectiveness of fixation process 5. If fixation process fails, no feasible method to recover fixated material	Eliminated
o Lake at its Full Condition	36.32	0.04	36.93			
o Lake at Drawdown Condition	35.73	0.04	36.34			
Alt. 3A - Removal/ Extraction/Sediments to Off-Site Nonhazardous Disposal/ Off-Site Hazardous Sludge Disposal				1. Same as Items 1, 4, 5, 6, 7 and 8 in Alt. 2A 2. Reduces mobility and toxicity of contaminants in sediments 3. Treated sediments believed to be delistable 4. Sludge generated from extraction process would be treated and disposed of at an off-site RCRA Facility	1. Extraction is well developed and reliable technology 2. Full-scale operation of extraction is commercially available 3. Treatability studies indicate the target level can be obtained 4. Extractant treatment process is a well-developed technology 5. The implementation facilities require a considerable space	Retained
o Lake at its Full Condition	27.09	0.04	27.71			
o Lake at Drawdown Condition	26.50	0.04	27.12			
Alt. 3B - Removal/Extraction/Sediments to On-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal				1. Same as Items 1, 4, 5, 6, 7 and 8 in Alt. 2A 2. Same as Items 2, 3 and 4 in Alt. 2A 3. Possible long-term environmental impacts on the landfill area 4. Minimizes transportation impacts on the environment	1. Same as Items 1, 2, 3, 4, and 5 in Alt. 3A 2. Nonhazardous landfill technology is conventional and available 3. State approval and community acceptance required for on-site nonhazardous landfill	Retained
o Lake at its Full Condition	22.06	0.228	25.57			
o Lake at Drawdown	21.47	0.228	24.98			Condition
Alt. 3C - Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal				1. Same as Items 1, 4, 5, 6, 7 and 8 in Alt. 2A 2. Same as Items 2, 3 and 4 in Alt. 3A 3. Possible long-term environmental impacts on lake due to lake deposition of the treated sediments.	1. Same as Items 1,2,3,4 and 5 in Alt. 3A 2. Lake deposition would be a simple technology	Retained
o Lake at its Full Condition	18.26	0.04	18.88			
o Lake at Drawdown Condition	17.67	0.04	18.29			

TABLE 3-2 (Cont'd)

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989) Capital	Annual O/M	Present Worth	Effectiveness	Implementability	Detailed Evaluation
Alt. 3D-Removal/Extraction/ Plant Site Deposition of Sediment/Off-Site Hazardous Sludge Disposal				1. Same as Items 1,4,5,6,7 and 8 in Alt. 2A 2. Same as Items 2,3 and 4 in Alt. 3A 3. Minimal adverse environmental impacts due to plant site deposition	1. Same as Items 1,2,3 and 4 in Alt. 3A 2. Plant site deposition would be a simple technology	Retained
o Lake at its Full Condition	$ 18.62	0.04	19.23			
o Lake at Drawdown Condition	$ 18.03	0.04	18.64			
CONTAINMENT						
Alt. 4A - Removal/Off-Site RCRA Landfill				1. Landfill does not attain SARA requirements 2. Landfill without treatment does not meet RCRA land disposal restriction requirements 3. Landfill does not achieve any reduction in volume or toxicity but may reduce mobility of contaminant on-site 4. Potential public health and environmental impacts due to handling and transportation 5. Does not attain ARARs	1. RCRA landfill is demonstrated and proven technology 2. Commercial RCRA landfill facilities are limited and require intensive administrative efforts 3. No long-term post-implement management is required 4. Dewatered sediments may require stabilization for off-site transportation and landfill	Eliminated
o Lake at its Full Condition	59.46	0.04	60.07			
o Lake at Drawdown Condition	58.87	0.04	59.48			
Alt. 4B - Removal/On-Site RCRA Landfill				1. Same as Items 1, 2, 3, and 5 in Alt. 4A 2. Long-term environmental impacts on the landfill areas would be possible 3. Minimizes transportation impacts on the environment	1. Same as Items 1 and 4 in Alt 4A 2. State approval and community acceptance for on-site hazardous landfill is questionable 3. Long-term post-implementation management is required	Eliminated
o Lake at its Full Condition	17.85	0.298	22.44			
o Lake at Drawdown Condition	17.26	0.298	21.84			

TABLE 3-2 (Cont'd)

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989)			Effectiveness	Implementability	Detailed Evaluation
	Capital	Annual O/M	Present Worth			
Alt. 5 - In Situ Sand Covering				1. Sand covering does not attain ARARs 2. Sand cover does not provide total reliable prevention of direct contact and ingestion risks 3. Adverse impacts on lake ecosystem 4. Potential erosion and disturbance and needs long-term maintenance 5. Cost-effective alternative	1. Implementation is relatively simple and available 2. Local traffic control and air pollution control are required 3. Sand covering is not stable and needs long-term administrative control	Retained
o Lake at its Full Condition	2.62	0.04	3.24			
o Lake at Drawdown Condition	Same as above					

4) Lake deposition and plant site deposition of extracted sediments are viable cost-effective methods of disposal and are retained for further evaluation. Lake deposition of the treated sediments in dredged/excavated areas would eliminate the cost of clean fill for these areas.

5) Sand covering is a cost-effective alternative that would minimize public health risks and environmental impacts and is retained for detailed evaluation.

A summary of the alternatives screened in this section and the results of the screening process are provided below.

Alternative	Description	Results
1	No Action	Retained
2A	Removal/Fixation/Off-Site Nonhazardous Landfill	Retained
2B	Removal/Fixation/On-Site Nonhazardous Landfill	Retained
2C	Removal/Fixation/Lake Deposition	Eliminated
3A	Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal	Retained
3B	Removal/Extraction/Sediments to On-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal	Retained
3C	Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal	Retained
3D	Removal/Extraction/Plant Site Deposition of Sediment/Off-Site Hazardous Sludge Disposal	Retained
4A	Removal/Off-Site RCRA Landfill	Eliminated
4B	Removal/On-Site RCRA Landfill	Eliminated
5	In Situ Sand Covering	Retained

SECTION 4.0

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4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a detailed evaluation of each remedial alternative that passed the initial screening in Section 3.0. Table 4-1 lists the alternatives to be analyzed in this section. Section 4.1 discusses the evaluation process used and the nine (9) criteria against which the alternatives are analyzed. The nine criteria are:

1. Short-Term Effectiveness
2. Long-Term Effectiveness
3. Reduction of Toxicity, Mobility or Volume
4. Implementability
5. Cost
6. Compliance with ARARs
7. Overall Protection of Human Health and the Environment
8. State Acceptance
9. Community Acceptance

Section 4.2 discusses the assessment of the remedial alternatives in which each alternative is described in detail and evaluated with respect to each of the nine criteria listed above.

4.1 EVALUATION PROCESS

The remedial alternatives are examined with respect to the requirements stipulated in CERCLA as amended, OSWER Directive No. 9355.0-19 (Interim "Guidance on Superfund Selection of Remedy", December 24, 1986), statutory factors described in OSWER Directive No. 9355.0-21 ("Additional Interim Guidance for FY'87 Records of Decision", July 24, 1987) and USEPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988a). A detailed analysis of alternatives consists of the following components and processes:

- Further definitions of each alternative, if appropriate, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

- Assessment and summary of each alternative against the nine criteria as defined by the OSWER Directive No. 9355.0-21.

- Comparative analysis among alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

TABLE 4-1

SOURCE CONTROL REMEDIAL ALTERNATIVES FOR DETAILED ANALYSIS

Alternative 1:	No Action
Alternative 2A:	Removal/Fixation/Off-Site Nonhazardous Landfill
Alternative 2B:	Removal/Fixation/On-Site Nonhazardous Landfill
Alternative 3A:	Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
Alternative 3B:	Removal/Extraction/Sediment to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
Alternative 3C:	Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal
Alternative 3D:	Removal/Extraction/Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal
Alternative 5:	In Situ Sand Covering

Each remedial alternative is evaluated with respect to the nine criteria presented below. At the completion of all detailed analyses, a summary section is included, whereby the statutory factors and criteria described in OSWER Directive No. 9355-021 are compared for each alternative to assist in the remedy selection process.

<u>Short-Term Effectiveness</u>: This evaluation criterion addresses the impacts of the alternative during the construction and implementation phase until the remedial action objective is met. Factors to be evaluated include protection of the community during remedial actions; protection of workers during the remedial actions; environmental impacts resulting from the implementation of the remedial actions; and the time required to achieve protection.

<u>Long-Term Effectiveness</u>: This evaluation criterion addresses the results of the remedial action in terms of the risk remaining at the site after the response objectives have been met, particularly the effectiveness of the controls that will be applied to manage the risk posed by treatment residuals and/or untreated wastes. The components of this criterion include the magnitude of the remaining risk measured by numerical standards such as cancer risk levels; the adequacy and suitability of controls used to manage treatment residuals or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals, i.e., the assessment of potential failure of the technical components.

The evaluation of the risks in this category will consider sediment exposure risks only. As discussed previously, there are existing increased health risks from exposure to the surface water and from ingesting fish. These risks will not necessarily be reduced through sediment remediation. However, the surface water risks may be reduced by stopping the source of arsenic entering the rivers, thereby reducing the water's arsenic concentrations. The fish ingestion risks may be reevaluated in the future. In either case, since sediment remediation is the focus of this FS, the risks associated with the sediments themselves will be the focus of the risk reduction for this evaluation criterion.

<u>Reduction of Toxicity, Mobility or Volume</u>: This evaluation criterion addresses the statutory preference that treatment is used to reduce the principal threats of the total mass of toxic contaminants, contaminant mobility, or the total volume of contaminated media. Factors of this criterion to be evaluated include the treatment process employed; the amount of hazardous material destroyed or treated; the degree of reduction in toxicity, mobility, and volume expected; and the type and quantity of treatment residuals.

Implementability: This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. Factors of technical feasibility include construction and operation difficulties, the reliability of technology, the ease of undertaking additional remedial action and the ability to monitor the effectiveness of the remedy. The administrative feasibility includes the ability and time required for permit approval and activities needed to coordinate with other agencies. Factors to evaluate the availability of services and materials include the availability of treatment, storage and disposal services with the required capacities; the availability of equipment and specialists; and the availability of prospective technologies for competitive bids.

Cost: The types of costs that should be addressed include capital costs, operation and maintenance (O&M) costs, costs of five year reviews (where required), the present worth of capital and O&M costs and potential future remedial action costs. Capital costs consist of direct and indirect costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install the remedial actions. Indirect costs include expenditures for engineering, financial, and other services required to complete the installation of the remedial alternatives. Annual O&M costs include auxiliary materials and energy, disposal of residues, purchased services, administrative costs, insurance, taxes, and license costs, maintenance reserve and contingency funds, rehabilitation costs and the costs of periodic site reviews.

This assessment evaluates the costs of remedial alternatives on the basis of present worth. Present worth analysis allows remedial alternatives to be compared on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. A required operating performance period is assumed for present worth and is a function of the discount rate and time. An operating performance period of 30 years and discount rate of 5% after inflation (OSWER 9335.3-01, page 7-24) are assumed for a base calculation. The "study estimate" costs provided for the alternatives are intended to reflect actual costs with an accuracy of -30 to +50 percent.

A cost sensitivity analysis assesses the effect that variations in specific assumptions associated with the design, implementation, operation, discount rate and effective life of an alternative have upon the alternative if there is sufficient uncertainty concerning the specific assumptions. Factors of a sensitivity analysis include risk-based target levels, effective life span, O&M costs, duration of cleanup, volume of contaminated material, size of the treatment system and discount rate.

Compliance with ARARs: This evaluation criterion is used to determine how each alternative complies with applicable or relevant and appropriate federal and state requirements as defined in CERCLA Section 121. Each alternative is evaluated in detail for:

- o Compliance with chemical-specific ARARs (e.g., MCLs);
- o Compliance with action-specific ARARs (e.g., RCRA minimum technology standards);
- o Compliance with location-specific ARARs (e.g., preservation of historic sites); and
- o Compliance with appropriate criteria, advisories, and guidances (e.g., "To Be Considered" material).

Table 4-2 presents a list of ARARs and "To Be Considered" (TBC) material that were used to evaluate the remedial alternatives. The table entries provide specific statutory or regulatory citations and their applications to the remedial alternatives evaluated in Section 4.2.

Overall Protection of Human Health and the Environment: This evaluation criterion provides an overall assessment of protection based on a composite of factors such as long-term and short-term effectiveness and compliance with ARARs. Evaluations of the overall protectiveness address:

- o How a specific alternative achieves protection over time;
- o How risks are reduced; and
- o How each source of contamination is to be eliminated, reduced, or controlled for each alternative.

State Acceptance: This assessment evaluates the technical and administrative issues and concerns the state may have regarding each of the alternatives. Factors of state acceptance to be addressed include features the State supports, has reservations about, and/or opposes.

Community Acceptance: This assessment incorporates public input into the analysis of alternatives. Factors of community acceptance to be discussed include features the community supports, reservations of the community and opposition of the community.

The State has reviewed the first draft of this FS and has provided comments to it which are incorporated into the report. However, the public has not been provided with a formal

TABLE 4-2

ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Contaminant - Specific:		
o Federal Clean Water Act Quality Criteria	Source Control	Ambient Water Standards for Surface Water used by NJ to develop their own standards.
o New Jersey Department of Environmental Protection Citation under the Environmental Cleanup Responsibility Act (ECRA) (ECRA-NJAC 7:103) New Jersey Soil Cleanup TBC for arsenic	Source Control	Soil cleanup action level
o NJ Surface Water Stds (NJAC 7:9-4, 14(c) and (d))	Source Control	Ambient stds for water treatment systems discharge-ing to surface water
Action - Specific:		
o Federal and NJ Hazardous Waste RCRA Treatment Storage and Disposal Facility Standards (40 CFR 264/265 and NJAC and 7:26-9, 10 and 11)	Source Control	General stds. for groundwater monitoring, closure, and post-closure activities
o Clean Water Act NJPDES Discharge to Surface Water Requirements (NJAC 7:14A-1 et seq, Appendix F)	Source Control	Stds. for water treatment systems discharging to surface water
		Design and operating stds., closure and post-closure activities for specific treatment systems

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ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Action-Specific (Cont'd)		
o Clean Water Act (Cont'd)		- Landfills - "Miscellaneous" units such as soil leaching, extraction, ion exchange, fixation and other chemical, physical, and biological treatment systems
o Federal Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions	Source Control	BDAT required prior to land disposal of certain contaminated wastes
o Federal and NJ Nonhazardous (Sanitary) Landfill Stds. (40 CFR 257/258 and NJAC 7:26-2A and 2)	Source Control	Design and operating stds for sanitary landfills
o Federal and NJ Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7)	Source Control	Off-site transport of treatment residues and excavated material
o OSHA-Recordkeeping, Reporting and Related Regulations	Source Control	General stds. outlining the recordkeeping, and reporting regulations

TABLE 4-2 (Cont'd)

ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Action-Specific (Cont'd)		
o OSHA Health and Safety Requirements for Hazardous Substance Responses (29 CFR 1910)	Source Control	Worker Protection stds. for all activities
o RCRA Characteristic Testing for Hazardous Waste Identification (40 CFR 261)	Source Control	EP Toxicity Test for determining whether a material is RCRA hazardous
o RCRA-Contingency Plan and Emergency Procedures	Source Control	General stds. for emergency contingency plans
o DOT Transportation Requirements for Hazardous Waste (40 CFR 100 - 177)	Source Control	Manifest system for hazardous waste transport
o NJ Toxic Substances Air Pollution Stds (NJAC 7:27-17)	Source Control	General prohibition on discharge of pollutants to air from storage tanks
o NJ Ambient Air Quality Stds. (NJAC 7:27-13)	Source Control	Stds. for limiting discharge of certain particulates
o National Historic Preservation Act	Source Control	Requires Stage 1A survey during remedial action
Location - Specific:		
o NJ Soil Erosion and Sediment Control Act of 1975 (NJSA 4:24-42) and Guidance	Source Control	Vegetative and engineering stds. to control sedimentation and conserve soil

TABLE 4-2 (Cont'd)

ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Action-Specific (Cont'd)		
o National Endangered Species Act	Source Control	Activities that affect endangered species
o US Fish and Wildlife Coordination Act	Source Control	Activities that affect fish or wildlife in stream areas
o Federal Floodplain and Wetlands Executive Order and Policy (#11990 and 11988) (40 CFR 6, Appendix A)	Source Control	Activities that affect floodplains and wetlands
o New Jersey Coastal Area Facility Review Act (CAFRA) Permit Requirements (NJSA 13:19-1 et seq)	Source Control	Activities affecting coastal areas
o New Jersey Wetlands (Coastal and Fresh) Permit Requirements (NJSA 13:9A-1 et seq, and 13:9B-1 et seq	Source Control	Activities affecting wetlands
o NJ Stream Encroachment Permit Standards (NJAC 7:8-3.15)	Source Control	Construction within 100-yr floodplain areas
o Rivers and Harbors Act Section 10 Clean Water Act Section 404 Stds	Source Control	Excavation activities in riverine areas may fall within "navigable waters of the US"

opportunity to review the detailed analysis of the remedial alternatives. A brief synopsis of state comments has been provided, but the public comments are not available. It is anticipated that the formal comments from the State and the public will be provided during the 30-day public comment period for this FS report. These comments will then be addressed in the ROD and responsiveness summary.

4.2 ASSESSMENT OF REMEDIAL ALTERNATIVES

Each source control (SC) alternative for the arsenic contaminated sediments in the Union Lake will be discussed in a separate subsection of Section 4.2. OSWER Directive No. 9355.0-19 recommends the development of SC alternatives ranging from an alternative that would eliminate the need for long-term management to alternatives involving treatment technologies to reduce the mobility, toxicity, or volume of contaminants. Containment options and a no action alternative are also part of this range of SC alternatives.

Alternative 1 (no action) involves limiting access to the identified contaminated areas of the site, conducting public education programs and instituting site-use restrictions. This alternative has no provisions for the treatment or containment of wastes. Alternatives 2A and 2B involve on-site treatment of arsenic-contaminated sediments by chemical fixation. The treated sediments would be landfilled as nonhazardous wastes off-site and on-site for Alternatives 2A and 2B, respectively. Alternatives 3A, 3B, 3C and 3D involve on-site treatment of arsenic-contaminated sediments by extraction (i.e., sediment water washing). The processed sediments would be landfilled as nonhazardous materials off-site and on-site for Alternatives 3A and 3B, respectively. Alternative 3C involves lake deposition of the water-washed sediments. Alternative 3D involves plant site deposition of the treated sediments. Alternative 5 provides containment of the sediments utilizing a sand layer, but does not include treatment.

4.2.1 <u>Alternative 1 - No Action</u>

4.2.1.1 Description

Under this alternative, a public education program would be provided and warning signs would be installed to minimize access to the site. Institutional administration would be established to limit the use of Union Lake. Warning signs would be posted at 500-foot intervals around the perimeter of the lake at prominent locations. Education programs, including public meetings and presentations, would be undertaken to increase public awareness.

Long-term monitoring of the lake would be performed to evaluate the performance of this alternative. This would consist of annual inspections as well as sampling the sediments and lake water every year for 30 years. Sixteen sediment samples and four lake water samples would be collected yearly and analyzed for arsenic. In addition, an ecosystem survey conducted during a site visit would be performed yearly. Because this alternative would result in contaminants remaining on-site, CERCLA as amended requires that the site must be reviewed every five years.

The major work items associated with this alternative are:

- Mobilize/demobilize;
- Install and maintain warning signs;
- Establish institutional control limiting the site use;
- Conduct annual inspection and water/sediment sampling to monitor contaminant concentration and migration;
- Conduct educational programs, including public meetings and presentations, to increase public awareness; and
- Perform a site review every five years.

4.2.1.2 Assessment

- Short-Term Effectiveness: This alternative would only restrict site access and use. No substantial construction would be involved in this remedial action. There are no short-term threats to neighboring communities and no significant impacts on public health and the environment during implementation activities. On-site workers would be properly protected with personal protection equipment against direct contact with and ingestion of contaminants in the sediments during the implementation of this alternative. Therefore the risks through direct contact with and ingestion of the sediments can be minimized. Education programs, including public meetings and presentations, would be presented to increase public awareness.

- Long-Term Effectiveness: The no action alternative would not reduce the level of sediment contamination in the lake and therefore the target risk level would not be attained. Some years may be required before natural degradative and transport mechanisms reduce the sediment arsenic concentration in the areas to be remediated to achieve the target risk level.

The alternative would be designed to prevent ingestion of and/or direct contact with the contaminated sediments by restricting access to the site. The long-term effectiveness of the alternative in minimizing baseline human health risks through the potential exposure pathways would depend on its success in preventing access to the site and use of the study area. The incremental lifetime cancer risks associated with exposure to sediments in areas to be remediated are greater than $2x10^{-6}$ and $1x10^{-5}$, the target cancer risk level for the more accessible areas and the less accessible areas respectively. If the access restrictions were unsuccessful, these risk levels might not decrease for some years.

This alternative would not improve the lake ecosystem. Additionally, the mobilization of arsenic contaminants from the sediments to the lake water may occur in the future.

o Reduction of Toxicity, Mobility or Volume: This alternative would not involve any containment, removal, treatment or disposal of the contaminated sediments. It would leave the contaminated sediments in place. Therefore, this alternative would not result in any reduction in the toxicity or mobility of contaminants. The lake's natural degradative and transport mechanisms may resuspend, disperse, and possibly leach the sediments to lake water. Therefore there may be a reduction in the volume of contaminated sediments in the lake over time. However, assuming all future arsenic releases to the lake were stopped, it might take some years for the natural dynamics of the lake to significantly reduce the volume of contaminated sediments.

Implementability

o Technical Feasibility: Posting warning signs is a relatively simple task, which could be performed by local contractors. The required equipment is readily available. The work could be completed within a relatively short period of time.

Once posted, warning signs would minimize site access. Routine inspection and the replacement of missing signs would be performed. Direct monitoring of the effectiveness of the alternative may be difficult, since it is impossible to determine if complete access restriction is achieved. Public awareness would increase the effectiveness of this alternative and regular public surveillance would deter access violations.

o Administrative Feasibility: Implementation of this alternative would require institutional controls to restrict recreational use of the lake. Considerable long-term institutional management would be associated with this alternative because wastes would remain on-site and a review would be necessary every five years. Annual inspections, sampling and public education programs (e.g., public meetings and workshops) would demand administrative and regulatory attention.

o **Cost**: The capital cost for this alternative, as outlined in Table B-1, is $44,450. Operation and maintenance costs for this alternative, outlined in Table B-9, are approximately $49,455 a year, for 30 years. The present worth cost, calculated at a discount rate of 5% after inflation, is $874,245. This cost represents all of the activities to post warning signs, implement institutional controls through public informing activities, and conduct six five-year reviews.

o **Compliance with ARARs**: ARARs for the No Action alternative apply to the posting of warning signs and the site monitoring activities. Requirements for these activities include OSHA Health and Safety Standards.

This alternative would not remove contaminated material from the site nor would it provide containment of contaminated sediment. It would provide only minimal protection to human health and the environment. The potential for the contaminants to migrate from the sediments into the lake water and the potential for human exposure to the contaminants would not be eliminated. As this is a No Action Alternative, it does not trigger LDR.

The river and lake are not RCRA units and therefore RCRA Clean Closure/Post Closure requirements may not be relevant.

o **Overall Protection of Human Health and the Environment**

The No Action alternative would not remove or contain the contaminated sediments. Institutional and educational controls would minimize the risk to public health. There would be no reduction in the toxicity or mobility of the contaminants. Some years may be required for the natural attenuation to reduce the arsenic concentration in the sediment in the shallow areas to below the cleanup level of 20 mg/kg in the more accessible areas and 120 mg/kg in the less accessible areas.

This alternative is not considered responsive to the remedial objectives, but provides a "base case" for comparison between other alternatives.

- State Acceptance: The state's comments regarding this alternative note that the no action alternative would be protective of human health through the implementation of public education programs and institutional controls to prevent site access.

- Community Acceptance: No public comments have been received to date.

4.2.2 Alternative 2A - Removal/Fixation/Off-Site Nonhazardous Landfill

4.2.2.1 Description

The major features of this alternative for the lake at its full condition include hydraulic dredging of contaminated sediments, sediment treatment and disposal, and supernatant water treatment and discharge. A schematic diagram is shown in Figure 4-1.

If remediation of the site were conducted when the lake is drawn down, the major features of this alternative would include excavation of the contaminated sediments, sediment fixation, and disposal of the treated material.

This is a source control (removal/treatment) alternative in which the contaminated sediments identified as a potential public health risk are removed and fixated. The processed sediments could be disposed of in an off-site nonhazardous landfill facility.

- Hydraulic Dredging

  If the remediation were conducted when the lake is at its full condition, hydraulic dredging would be performed to remove contaminated submerged sediment to a depth of approximately 1.0 foot. Hydraulic dredges remove and transport sediment in a liquid slurry form which contains approximately 10 to 20% solids by volume. It is expected that the lake water would provide a minimum water depth to maintain hydraulic dredge mobility.

  A "portable" dredge is a type of hydraulic dredge that is designed for use in shallow bodies of water and industrial settling ponds, and is transportable by truck. One of the most widely used portable dredges is the Mud Cat dredge, whose applications to date have included dredging small reservoirs, streams and industrial ponds. The Mud Cat is also known as a horizontal-auger dredge.

  The Mud Cat is pontoon-mounted and features a horizontally mounted, auger-like cutting device that feeds the excavated sediment to a suction intake of a diesel-driven centrifugal pump producing an 8 ft-wide cut. The auger is

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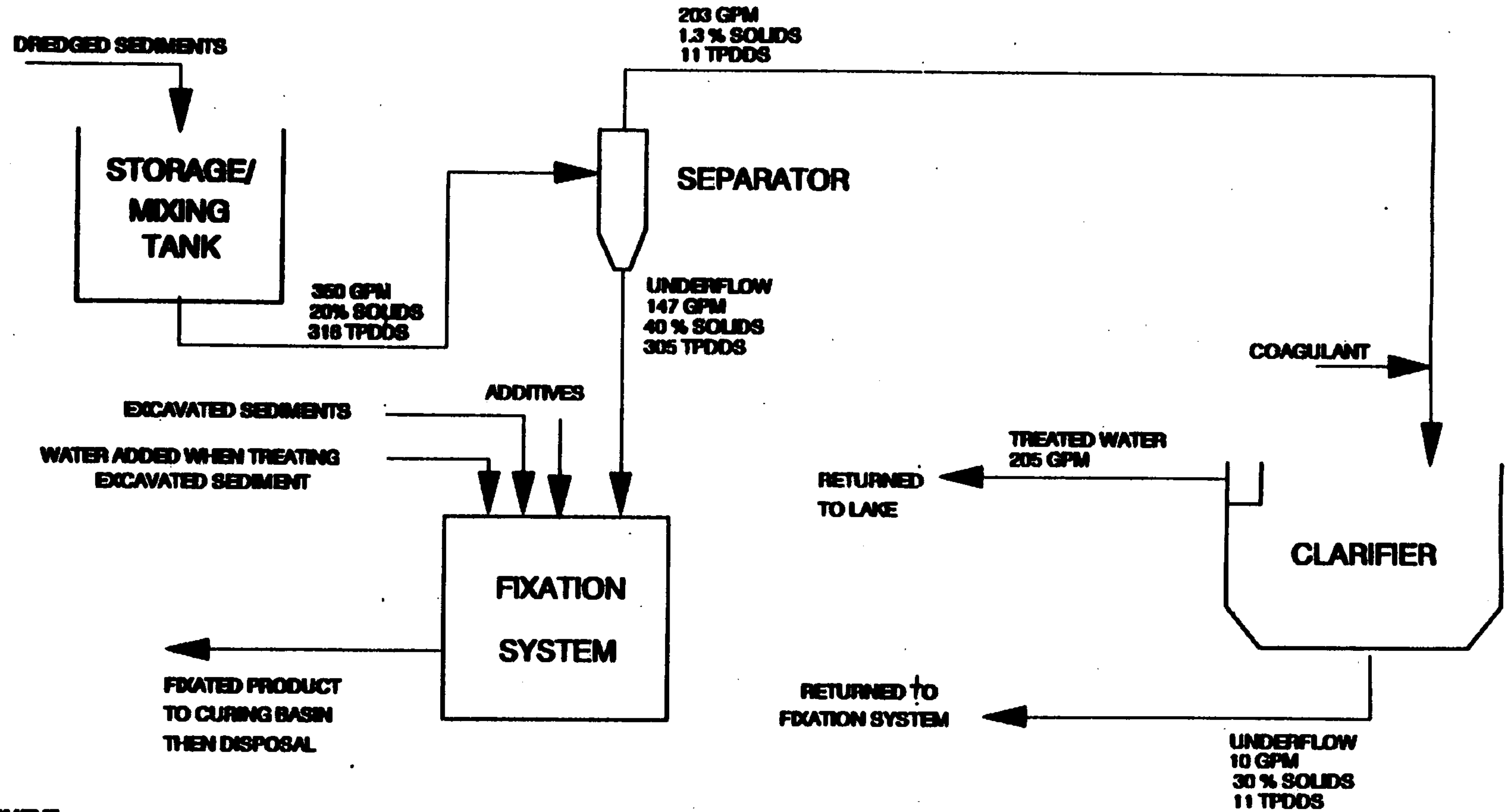
FIGURE 4-1
FIXATION SYSTEM



COMMENT:

1. SYSTEM OPERATES WITH EITHER THE DREDGED SEDIMENTS OR THE EXCAVATED SEDIMENT.
2. ONLY THE FIXATION SYSTEM IS NEEDED WHEN THE EXCAVATED SEDIMENTS ARE TREATED.
3. THE FLOW RATES ARE FOR THE DAYTIME (8 HOURS/DAY) OPERATION. FOR 16 HOURS/DAY THE OPERATION IS AT 50 % OF THE FLOW RATES SHOWN.
4. % SOLIDS IS ON A WEIGHT BASIS.
5. THE TONS PER DAY OF DRY SOLIDS (TPDDS) IS COMPUTED FOR 24 HOURS AT THE ACTUAL RATES.

mounted along the base of a bulldozer-type blade. The entire configuration, with suction pipe attached, is controlled by a hydraulic boom. The dredge is moved along on an anchored cable during each traverse of excavation, and the dredged material is discharged ashore through a float-supported pipeline.

The Mud Cat is considered to be the best dredge qualified for use in Union Lake and has been selected for the following reasons:

1. Small size - The Mud Cat can be transported to the site by a conventional tractor-trailer truck and placed in the water by crane.

2. Shallow draft - It draws just under 2 ft.

3. Low resuspension of sediments during dredging activities - Based on recent studies by the US Army Corps of Engineers for the USEPA, Mud Cat dredging equipment can be operated to produce a resuspension plume that does not migrate from the immediate vicinity of the dredge intake. Accomplishing this does come at the expense of dredge optimization, since flows must be increased to pull in more water to minimize the size of the plume. As an added precaution, silt curtains will be situated downstream to capture resuspended sediment. Transport modeling with dye studies would enable strategic placement of silt curtains during final design.

Two Mud Cats could dredge sediments at a combined rate of approximately 100 cubic yards of sediment/slurry per hour, eight hours a day. Approximately 131,000 cubic yards of sediment (in-place volume, assuming 54% solids and 46% water as the in-place sediment density) could be removed by the Mud Cats over a period of approximately two years. The total pumping rate of the water-sediment slurry with approximately 20% solids by volume would be approximately 350 gpm. The slurry would be pumped through a floating piping system to an on-site treatment facility. Clean sand would be used to restore the dredged areas.

o **Excavation**

Sediment excavation would be implemented if remediation were conducted with the lake at drawdown condition. It would be expected that the exposed sediments would be sufficiently dried to perform dry excavation. Approximately 131,000 cubic yards of exposed sediment would be removed.

The exposed sediment would be removed from the contaminated areas using a backhoe. A low ground pressure backhoe, which is used for excavating soft material, may be required for the sediment. Additionally, other standard excavation equipment, bulldozers, front-end loaders and clam shells would be utilized when appropriate. The sediment would be transported directly to an on-site treatment facility. Clean sand would be used to restore the excavated areas.

o **Sediment Chemical Fixation**

The sediment would be treated at a facility constructed on the designated site using the chemical fixation system shown in Figure 4-1. Due to the size of the lake and the remoteness of the areas that are to be treated, the treatment facility would be relocated several times during the remediation. Therefore, portable equipment and/or equipment that can be disassembled and reassembled easily is preferred. The dredged sediment would first be thickened by means of 14 hydroclones operating in parallel. Seven hydroclones would operate while the other seven would be on standby. The excavated sediment would not require thickening and would be transported directly to the fixation system by trucks and fed by means of belt elevators. The sediment would be treated in mixing tanks using the fixation process. The addition of water would be required for the excavated sediments to achieve the proper formulation for fixation. The fixated sediments would be cured in an on-site storage area for a specified period of time (approximately 48 hours) to complete the fixation/stabilization process.

Bench-scale tests were performed to prove the feasibility of chemical fixation for the contaminated sediment by utilizing a commercial proprietary "K-20/LSC" process. The "K-20/LSC" process is based upon a chemical treatment utilizing three components: sediments, a dry reagent and a liquid reagent. The dry reagent is made from Portland cement, fly ash and activated carbon powder. The liquid reagent is a commercial silicated blend known as K-20/LSC, which has been developed and manufactured by Lopat Enterprises, Inc. of Wanamassa, New Jersey. The K-20/LSC System has been demonstrated and proven to be effective, having the ability to be custom-blended as needed for a particular application.

The sediment and dry reagent would be thoroughly blended in specially designed high-powered mixing tanks. After blending, the liquid reagent would be injected into the mass and further blending would take place. A rapid chemical reaction would occur, transforming the product into a gel. The gel would then be extruded into a confinement (curing basin) where it would be kept for 48 hours. The fixated product in the treatability test achieved an unconfined compressive strength (UCS) of approximately 9,000 psf, which significantly exceeded the required design strength of 1,500 psf.

The resulting product would be chemically fixated and physically stabilized. All constituents of concern, such as arsenic, would be bound within the K-20/LSC gel. The product would be a solid with a rock-like appearance and would be suitable for landfill disposal. Details of the test results are given in Section 6 and Appendix A of the Union Lake RI Report (Ebasco, 1989e).

- Supernatant Water Treatment

  The overflow from the thickeners would be directed into two clarifiers 20 ft in diameter by 10 ft high. Alum, ferric chloride and polymer would be added and mixed in order to remove suspended solids and reduce arsenic concentrations to below 0.05 mg/l. The clarified supernatant would then be tested and returned to Union Lake via a discharge system. The settled solids from the clarifiers would be pumped back to the fixation units and would be treated in the same manner as the contaminated sediments. In order to optimize this system, a pilot-scale study would be required. The excavated sediments would not require thickening and thus no supernatant would be generated.

- Off-Site Nonhazardous Disposal

  The fixated sediment would be loaded onto trucks for transport to a nearby nonhazardous landfill. This means of disposal would be preceded by a NJDEP ID 27 waste classification for the treated sediments. The total volume of fixated sediment is estimated to be 117,000 cubic yards, free of water. The trucks would be lined, sealed, and decontaminated prior to leaving the site.

The major construction components and facilities for this alternative are outlined in Table A-2 of Appendix A.

4.2.2.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness concerns with this alternative include public health threats, adverse impacts on the environment and the safety of workers during the implementation activities. The potential public health threats to area residents would include direct contact with spilled wastes and the inhalation of fugitive dust. The sediment treatment plant would be located, at a minimum, 500 feet away from the nearest recreational facility or house. The entire treatment plant would be fenced and warning signs would be posted. Access would be limited to authorized personnel only. The sources of fugitive dust emissions include dried sediment, cement and fly ash used in the fixation process. The storage and handling of these materials would be performed in a closed silo and in a vessel equipped with proper dust control devices. The fixated sediments waiting to be transported off-site would be contained to prevent release to the environment. Therefore the short-term public health threats resulting from this remedial action would be minimal.

Hydraulic dredging operations would result in localized sediment resuspension and could temporarily affect biota. Since hydraulic dredging would be limited to local shallow water areas, suspensions would settle in a short period of time, enabling fish and wildlife to have adequate room to avoid the disturbed area. The use of Union Lake would be restricted during the operation. The adverse effects on the lake ecosystem and the environment would be temporary and localized.

Excavation of the exposed sediments would pose potential public health threats to area residents and on-site workers. During the excavation process, proper dust suppression measures would be practiced to prevent the generation of contaminated dust.

The on-site risk to workers would be minimized by the use of adequate preventive measures and proper personnel protective equipment, which would prevent direct contact with wastes and the inhalation of fugitive dust. All unit operations such as thickening, fixation, curing and transportation would be performed with adequate containment (tanks, vessels and silos) and in confined areas. The chemical reaction involving the sediments and additives would not produce off-gases. Any leachate or drainage generated from the curing basin would be collected and treated for suspended solids. The supernatant would be tested for arsenic prior to being discharged to the lake. The short-term risks to workers would be minimal.

The short-term impacts on the environment include increased traffic and construction operations in the area. The trucks transporting the fixated sediments would be decontaminated and covered; however the passage of trucks through the neighboring communities could have some impact. Additional traffic could cause noise pollution, a possible increase in accidents and air pollution. On-site safety issues would include the truck traffic, accidents, noise and airborne particulates from transporting the fixed sediment. An appropriate local traffic control plan would be implemented by the local authorities. Proper dust control measures such as water spraying would be practiced to minimize air pollution.

The time required to complete this remedial action is estimated at approximately three years.

o <u>Long-Term Effectiveness</u>: Immobilization through chemical fixation is designed to render contaminants insoluble, prevent leaching from the fixated wastes, reduce the potential of direct human contact, and improve waste handling characteristics. This alternative would reduce the mobility of the contaminants; it would not achieve any reduction in volume and toxicity. Chemical fixation would convert contaminated sediments into a stable cement-type matrix with minimal free water. The supernatant separated from the dredged sediments would be treated using physical-chemical precipitation processes in order to remove arsenic to levels below 0.05 mg/l prior to discharge to Union Lake.

The major long-term effectiveness concern would include any beneficial and adverse impacts on public health and the environment that might result from the completion of this remediation. The major benefit associated with this alternative is that sediments that have been determined as a public health risk would be removed and treated. This action would reduce the potential public health risks and would facilitate lake restoration for public use. The reduction of contaminant load in these sediments would minimize the possible ingestion risk during recreational use of the lake. The cancer risk for arsenic via the ingestion exposure pathway would thereby be reduced to approximately 2×10^{-6} in the more accessible areas and 1×10^{-5} the less accessible areas; however, sediments exceeding the target level would remain in the lake.

If contaminated sediments remain in the lake, natural water dynamics, human disturbance and the growth of vegetation may redistribute them. Any of these occurrences may result in previously clean areas exceeding the action level, or may result in previously contaminated areas becoming clean. Therefore a long-term monitoring plan would be required to measure the effectiveness of this alternative. Additional remedial activities may be required in the future if significant redistribution of contaminated sediment occurs. In addition, because this alternative would result in contaminated sediments remaining on-site (in the lake), CERCLA as amended, would also require that the site be reviewed every five years to determine the effectiveness of the alternative or to identify new technologies that could be applied to the problems of this particular site.

No adverse environmental impacts are expected to result from the implementation of this alternative. As this alternative would remove contaminated sediments under a maximum fire foot water depth, dredging would occur in shallow water areas. Impacts from dredging operations would be kept at a minimum by controlling the sediment resuspension plume by varying the intake flow rate. Impacts from excavation operations would be kept to a minimum by utilizing dust suppression techniques. Any wetland areas that might be disturbed during the implementation of this alternative would be identified and taken into consideration for restoration during final design.

The fixated sediment would be transported and disposed of in a nearby licensed off-site nonhazardous landfill facility. This facility would not be expected to pose public health risks or risks to the environment since it would be a fixed facility in compliance with all appropriate regulations and since the mobility of the arsenic in the fixed sediments is low.

o <u>Reduction of Toxicity, Mobility or Volume</u>: Immobilization is well suited for solidifying sediments containing heavy metals and other inorganics such as arsenic. This form of fixation is generally affected by the sediment matrix, contaminant constituents, and the fixation additives. Many of the commercially available processes use proprietary additives and claim to stabilize a broad range of compounds from divalent metals to organic wastes. Some research results (USEPA, 1985b) indicate that successful fixation of arsenic-contaminated sediment could be obtained by utilizing a modified process that involved the use of sodium silicates.

Sediment chemical fixation has been designed based on the results of bench-scale treatability tests including three different additive formulations (see Union Lake RI Report Section 6.0). The treatability test results indicated that samples consisting of sediments, K-20/LSC, activated carbon, Portland cement and fly ash might meet the performance criteria. After 48 hours of curing, the mixture yielded RCRA EP Toxicity Test results of approximately 1 mg/l of leachable arsenic. The fixated sample would have approximately 9,000 lb/ft^2 of unconfined compressive strength (UCS), which is much higher than the 1,500 lb/ft^2 generally required for landfilling to support truck traffic and other earth-moving equipment. In addition, the sample yielded USEPA Multiple Extraction Procedure (MEP) results with maximum arsenic leachate concentration of 0.32 mg/l. Th MEP is used to estimate the long-term stability of th treated material under conditions simulating 1,000 year

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of exposure to acid rain (48 CFR 52686-87, November 22, 1982). Based on these test results, as well as the discussion presented in Subsection 3.1.1.2.2, it is assumed that the fixation process could be optimized to enable delisting of the fixated sediments.

K-20/LSC is an inorganic silicate-based material that has the following major functions contributing to successful fixation:

- o Precipitation of inorganic arsenic;
- o Encapsulation of arsenic contaminants;
- o Protection and stabilization of encapsulated arsenic contaminants; and
- o Activated carbon powder adsorption of organic arsenic in a fixated matrix.

Based on the MEP test data, the treatment processes used for this alternative would be irreversible, and arsenic bound in the sediment would not be expected to be leachable. Thus chemical fixation would provide an almost permanent remedy by reducing the total mobility of both inorganic and organic arsenic in the contaminated sediments that are treated. The off-site nonhazardous landfilling of the fixated sediments would also provide an adequate containment for reducing the mobility of contaminants, but would not contribute to the overall reduction in the toxicity or volume of the contaminants. The chemical fixation process would result in an increase in the volume and weight of material after treatment is complete.

This alternative would greatly reduce the mobility of arsenic sediments that pose threats to human health. The toxicity of Union Lake water in the areas of concern may be reduced as a consequence of reducing the suspension of contaminated solids and the phase transfer of soluble arsenic.

Implementability:

- o Technical Feasibility: This alternative involves on-site hydraulic dredging or dry excavation, chemical fixation, supernatant treatment and off-site nonhazardous landfilling. These are all well-developed and proven technologies and are commercially available. Hydraulic dredging for shallow water sediment removal, using equipment such as a Mud Cat, can be provided by many vendors and is

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readily available for lease or purchase. Excavation using standard equipment, such as a low ground pressure backhoes can be provided by several vendors.

Chemical fixation technologies are commercialized and can be provided by many manufacturers with their own proprietary blends. The commercial silicate blend used for the treatability study was selected because of its ability to be custom-blended as needed for a particular application. Similar blends are available from other vendors if the necessity arises. Other materials required for chemical fixation, such as Portland cement, fly ash, and activated carbon powder, are all common industrial materials commercially available. The equipment required for chemical fixation includes standard cement mixing and handling facilities, which are also commercially available.

The supernatant from the dredged sediment would require treatment. The physical-chemical precipitation treatment systems are traditional industrial wastewater treatment processes which can be installed with off-the-shelf hardware. Nonhazardous landfill facilities are available within a reasonable distance from the site and have indicated a willingness to accept these treated materials.

Hydraulic dredging can easily be performed to depths below the expected limit of contamination (one foot). On-site sediment and water testing would be required to monitor the Mud Cat's effectiveness. One pass of the Mud Cat over an area can remove approximately 1.5 feet of sediment. If necessary, a second pass over the same area could be performed to meet the specified cleanup level.

Dry excavation utilizing equipment including a backhoe and bulldozer can also be easily performed to depths below the expected limit of contamination. It is expected that the exposed sediments would be sufficiently dry to facilitate the use of dry excavation techniques. Any contaminated sediment located along the lake shore would be removed utilizing backhoes or a clam shell scoop. The sediment at the northern end of the lake may exhibit marsh-like properties necessitating the use of a low ground pressure backhoe. The condition of the lake will be taken into consideration during final desi in the determination of the best method of excavatior

The chemical fixation process utilizing conventional cement mixing and blending equipment could handle many variations in sediment composition. The solidification/fixation/stabilization of sediments to achieve an arsenic leachate concentration below the target level of 0.32 mg/l would be simple from a technical standpoint; there are no appreciable construction or operation difficulties anticipated for the fixation system. Similarly, the construction and operation of the supernatant water treatment system is not expected to encounter any unknown problems.

The chemical fixation process provides a reliable method for meeting all performance goals. It would be unlikely that any technical difficulties would lead to schedule delays. Labor and materials are readily available for all components of this alternative. The relatively complex components of this alternative are sediment fixation and water treatment; however, these are proven technologies. The other components are comparatively simple.

Conditions external to the site, such as equipment and disposal facility availability, present no known problems at this time. This remedial alternative provides a reliable process for handling the contaminated sediment.

The time required for implementation of this remedial alternative is approximately 24 months. If the need arises to treat more or less sediments than anticipated, this could be accomplished by extending or shortening the remediation period. Beneficial results (i.e., to reuse the lake for recreational purpose) would be achieved almost immediately following the completion of the construction.

o <u>Administrative Feasibility</u>: Treated overflow from the sediment thickening operations associated with dredging would be returned to Union Lake. A discharge permit would not be required since this is an on-site Superfund discharge. However, a statement that this discharge would be in compliance with ARARs would be required for state and local approval. Since the overflow would be treated to meet the Safe Drinking Water Standards and New Jersey Surface Water Quality Standards, the state and local approvals for discharge to the lake should not pose a problem.

Institutional administration would be required t locate a nearby nonhazardous landfill site that coul accept the fixated sediments. Since the waste woul be disposed of off-site, NJDEP would be responsibl for approving the delisting petition. This could result in a relatively lengthy process. Based on the results of the treatability study, with confirmation from the vendor, and with concurrence from USEPA Region II, the fixed sediment is expected to meet delisting requirements, and therefore disposal at a nonhazardous landfill would not be expected to pose any problems other than time considerations for approval. Following the delisting process, the NJDEP would make the determination of whether or not the material is ID 27 waste. The classification of the treated sediment as ID 27 waste would require landfilling of the material in a permitted facility.

In addition, coordination with the local traffic authorities would be required to control the additional traffic for transporting the treated solids. An appropriate local traffic control plan would be implemented by the local authorities.

- Cost: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at drawdown. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-2, is estimated to be $34,591,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table B-10, are approximately $20,562,000 and $13,000, respectively. The present worth cost calculated at a discount rate of 5% after inflation, is $71,247,000. This represents all of the activities to dredge, thicken, fixate, haul and landfill the sediments and to treat the contaminated supernatant; to perform all operation and maintenance functions on the treatment system components; to perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

  A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs, considering the lake at its full condition, were $120,708,000 and $197,861,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +69% to 178% over the estimated present worth cost of the base case alternative. The costs are summarized in Table 4-3. Figure 4-2 presents a graphical representation of the sensitivity costs.

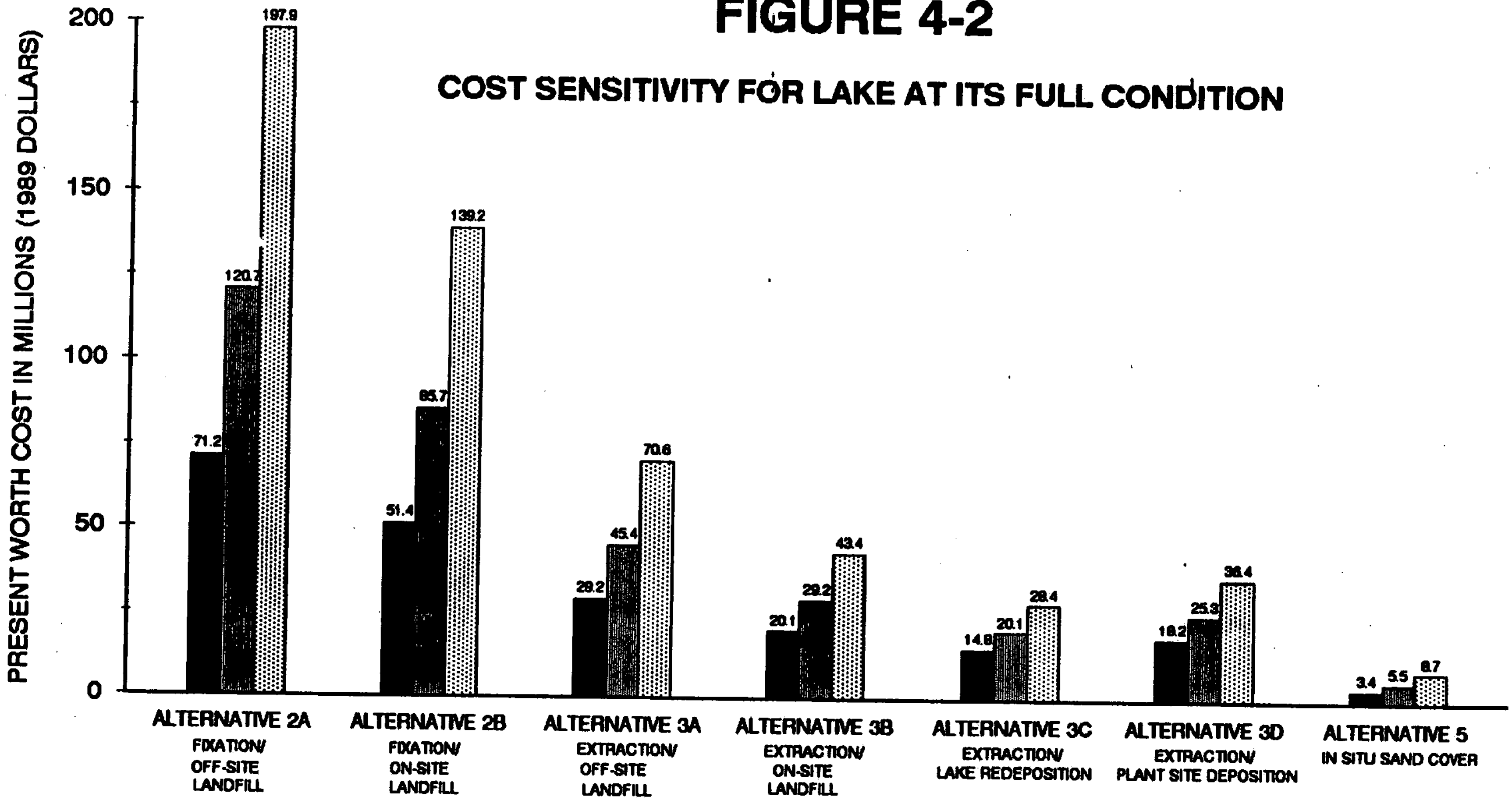
TABLE 4-3
SENSITIVITY ANALYSIS OF COSTS (1989 DOLLARS)
BASED UPON HAZARDOUS SEDIMENT QUANTITIES
UNDERLYING VARYING DEPTHS OF WATER
DREDGING CASE

ALT	DEPTH OF WATER (FT.)	CAPITAL COST DIRECT	CAPITAL COST INDIRECT	CAPITAL COST TOTAL	ANNUAL O & M LONG TERM	ANNUAL O & M SHORT TERM	PRESENT WORTH
1	DOES NOT APPLY	$ 35,000	$ 9,450	$ 44,450	$ 49,455	$	$ 874,245
2A	BASE CASE	$27,237,097	$ 7,354,016	$34,591,113	$ 13,020	$20,562,475	$ 71,246,971
	5.0	$45,885,757	$12,389,154	$58,274,911	$ 13,020	$35,119,015	$120,708,466
	10.0	$74,975,032	$20,243,259	$95,218,291	$ 13,020	$57,825,162	$197,861,414
2B	BASE CASE	$10,820,246	$ 2,921,466	$13,741,712	$ 89,530	$20,562,475	$ 51,413,566
	5.0	$16,958,543	$ 4,578,807	$21,537,350	$ 144,901	$35,119,015	$ 85,722,192
	10.0	$26,533,418	$ 7,164,023	$33,697,441	$ 231,273	$57,825,162	$139,238,806
3A	BASE CASE	$20,268,107	$ 5,472,389	$25,740,496	$ 13,020	$ 1,832,012	$ 29,227,193
	5.0	$32,510,477	$ 8,777,829	$41,288,306	$ 13,020	$ 2,186,175	$ 45,402,179
	10.0	$51,606,845	$13,933,848	$65,540,693	$ 13,020	$ 2,738,620	$ 70,632,873
3B	BASE CASE	$12,611,824	$ 3,405,192	$16,017,016	$ 60,398	$ 1,832,012	$ 20,132,854
	5.0	$18,918,147	$ 5,107,900	$24,026,047	$ 93,907	$ 2,186,175	$ 29,214,039
	10.0	$28,755,120	$ 7,763,882	$36,519,002	$ 146,176	$ 2,738,620	$ 43,379,406
3C	BASE CASE	$ 8,870,451	$ 2,395,022	$11,265,473	$ 13,020	$ 1,832,012	$ 14,752,170
	5.0	$12,559,517	$ 3,391,070	$15,950,587	$ 13,020	$ 2,186,175	$ 20,064,460
	10.0	$18,313,940	$ 4,944,764	$23,258,704	$ 13,020	$ 2,738,620	$ 28,350,883
3D	BASE CASE	$11,610,914	$ 3,134,947	$14,745,861	$ 13,020	$ 1,832,012	$ 18,232,558
	5.0	$16,705,285	$ 4,510,427	$21,215,712	$ 13,020	$ 2,186,175	$ 25,329,585
	10.0	$24,651,783	$ 6,655,981	$31,307,764	$ 13,020	$ 2,738,620	$ 36,399,944
5	BASE CASE	$ 2,476,276	$ 668,594	$ 3,144,870	$ 13,020	$	$ 3,368,883
	5.0	$ 4,118,010	$ 1,111,863	$ 5,229,873	$ 13,020	$	$ 5,453,886
	10.0	$ 6,678,884	$ 1,803,299	$ 8,482,183	$ 13,020	$	$ 8,706,196

lake is at its full condition.

FIGURE 4-2

COST SENSITIVITY FOR LAKE AT ITS FULL CONDITION



	DEPTH OF WATER	VOLUME OF SEDIMENT
(black)	2.5 ft.	130,608 cubic yards
(dark shaded)	5.0 ft.	228,622 cubic yards
(light dotted)	10.0 ft.	381,510 cubic yards

** NOTE: SEDIMENT VOLUMES BASED ON UPON WATER DEPTHS WHEN THE LAKE IS FULL

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 4-2
SENSITIVITY OF REMEDIATION COSTS TO WATER DEPTH USING DREDGING OPERATIONS

EBASCO SERVICES INCORPORATED

LAKESEN61

VIN 002 0400

The capital cost for this alternative with the lake at drawdown, as outlined in Table C-1, is estimated to be $32,317,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table C-8, are approximately $20,487,000 and $13,000, respectively. The present worth cost calculated at a discount rate of 5% after inflation, is $68,840,000. This represents all of the activities to excavate, fixate, haul and landfill the contaminated sediments; perform all operation and maintenance functions on the treatment system components; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at drawdown condition were $116,783,000 and $191,567,000 for the five-foot water depth and ten foot water depth, respectively. These costs represent a difference of +69% to 178% over the estimated present worth cost of the base case alternative. The costs are summarized in Table 4-4. Figure 4-3 presents a graphical representation of the sensitivity costs.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth cost of the alterative, assuming no disposal costs, is $44,466,000 and $42,059,000 for the lake at its full condition and the lake at drawdown, respectively.

In the event that the treated sediments cannot be considered delistable, off-site RCRA landfilling would be required. The present worth costs for this alternative, considering RCRA disposal of the treated sediments when the lake is at its full condition and when the lake is drawn down are $105,646,000 and $103,239,000, respectively.

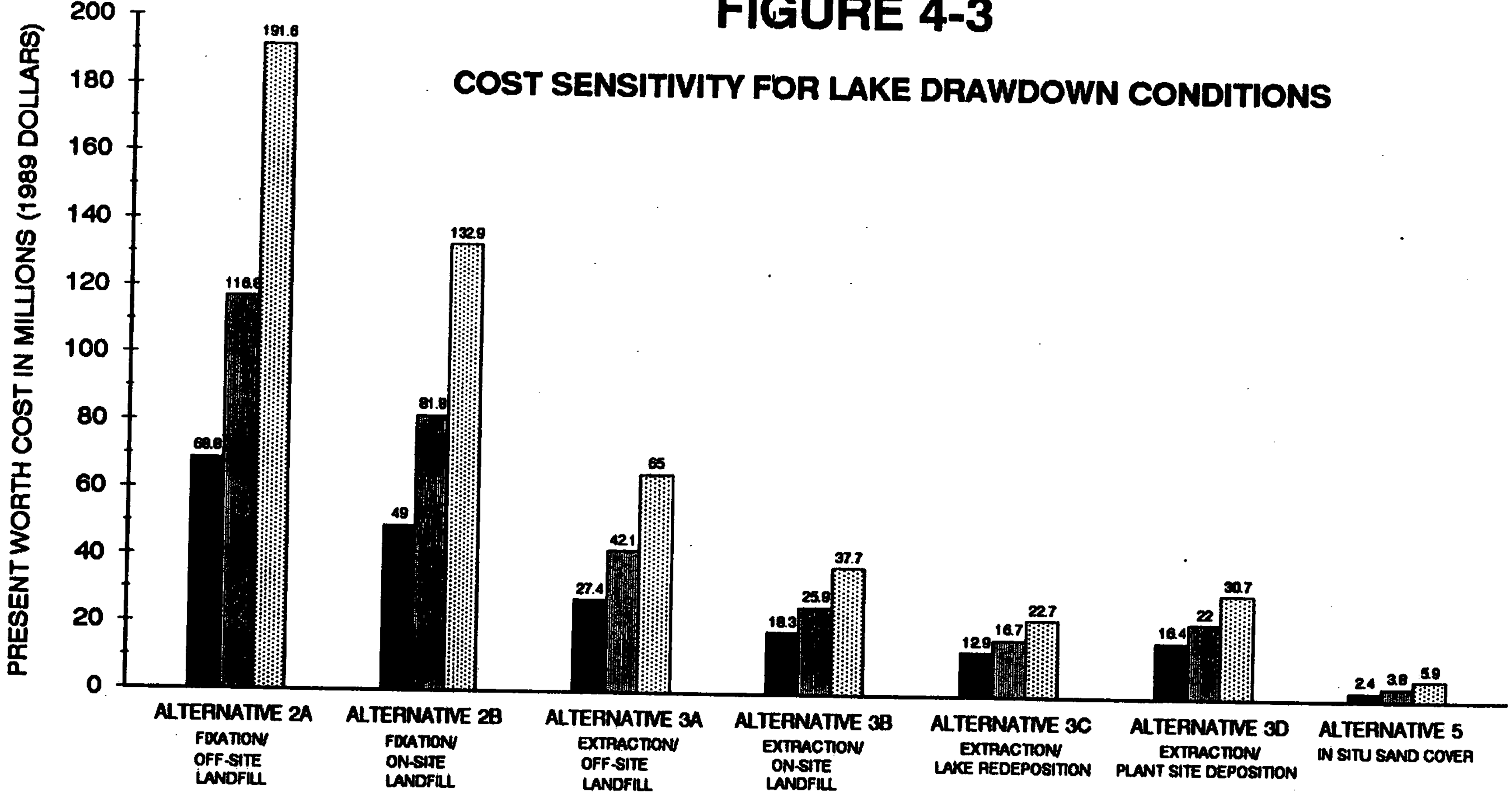
TABLE 4-4
SENSITIVITY ANALYSIS OF COSTS (1989 DOLLARS)
BASED UPON HAZARDOUS SEDIMENT QUANTITIES
UNDERLYING VARYING DEPTHS OF WATER
EXCAVATION CASE

		CAPITAL COST			ANNUAL O & M		PRESENT WORTH
ALT	DEPTH OF WATER (FT.)	DIRECT	INDIRECT	TOTAL	LONG TERM	SHORT TERM	
1	DOES NOT APPLY	$ 35,000	$ 9,450	$ 44,450	$ 49,455	$	$ 874,245
2A	BASE CASE	$25,446,160	$ 6,870,463	$32,316,623	$ 13,020	$20,487,428	$ 68,839,581
	5.0	$42,948,533	$11,596,104	$54,544,637	$ 13,020	$35,008,867	$116,783,134
	10.0	$70,249,461	$18,967,354	$89,216,815	$ 13,020	$57,659,996	$191,567,450
2B	BASE CASE	$ 9,029,350	$ 2,437,925	$11,467,275	$ 89,530	$20,487,428	$ 49,006,227
	5.0	$14,021,269	$ 3,785,743	$17,807,012	$ 144,901	$35,008,867	$ 81,796,799
	10.0	$21,807,882	$ 5,888,128	$27,696,010	$ 231,272	$57,659,996	$132,944,884
3A	BASE CASE	$18,876,051	$ 5,096,534	$23,972,585	$ 13,020	$ 1,808,043	$ 27,416,835
	5.0	$29,972,087	$ 8,092,464	$38,064,551	$ 13,020	$ 2,133,364	$ 42,084,902
	10.0	$47,280,151	$12,765,641	$60,045,792	$ 13,020	$ 2,640,815	$ 64,964,770
3B	BASE CASE	$11,219,788	$ 3,029,343	$14,249,131	$ 60,397	$ 1,808,043	$ 18,322,520
	5.0	$16,379,733	$ 4,422,528	$20,802,261	$ 93,907	$ 2,133,364	$ 25,896,734
	10.0	$24,428,443	$ 6,595,679	$31,024,122	$ 146,176	$ 2,640,815	$ 37,711,324
3C	BASE CASE	$ 7,478,424	$ 2,019,174	$ 9,497,598	$ 13,020	$ 1,808,043	$ 12,941,849
	5.0	$10,021,093	$ 2,705,695	$12,726,788	$ 13,020	$ 2,133,364	$ 16,747,140
	10.0	$13,987,261	$ 3,776,560	$17,763,821	$ 13,020	$ 2,640,815	$ 22,682,800
3D	BASE CASE	$10,218,882	$ 2,759,098	$12,977,980	$ 13,020	$ 1,808,043	$ 16,422,231
	5.0	$14,166,866	$ 3,825,054	$17,991,920	$ 13,020	$ 2,133,364	$ 22,012,271
	10.0	$20,325,109	$ 5,487,779	$25,812,888	$ 13,020	$ 2,640,815	$ 30,731,867
5	BASE CASE	$ 1,713,651	$ 462,686	$ 2,176,337	$ 13,020	$	$ 2,400,349
	5.0	$ 2,783,088	$ 751,434	$ 3,534,522	$ 13,020	$	$ 3,758,534
	10.0	$ 4,451,251	$ 1,201,838	$ 5,653,089	$ 13,020	$	$ 5,877,101

ter depth assumes lake is at its full condition.

FIGURE 4-3

COST SENSITIVITY FOR LAKE DRAWDOWN CONDITIONS



	DEPTH OF WATER	VOLUME OF SEDIMENT
■ (solid)	2.5 ft.	130,608 cubic yards
■ (dark stipple)	5.0 ft.	228,622 cubic yards
░ (light stipple)	10.0 ft.	381,510 cubic yards

** NOTE: SEDIMENT VOLUMES BASED ON UPON WATER DEPTHS WHEN THE LAKE IS FULL

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 4-3
SENSITIVITY OF REMEDIATION COSTS TO WATER DEPTH FOR DRAWDOWN REMEDIATION

EBASCO SERVICES INCORPORATED

LAKESENS2

VIN 002 0403

o **Compliance with ARARs**

The Rivers and Harbors Act Section 10 regulation requires that adequate preventive measures be provided to minimize disturbance to lacustrine areas. Hydraulic dredging activities in the lake would require appropriate preventive measures to minimize resuspension, erosion, and dissolved oxygen depletion. If excavation were implemented, preventive measures to minimize erosion of the lake shores would be required.

The lacustrine areas would be within the broader "waters of the U.S." jurisdiction of Section 401 and Section 404 of the Clean Water Act (CWA). Section 401 of the CWA requires that any activity must not result in a discharge that violates water quality criteria based on existing water quality and water body classifications.

Section 404 specifically requires that no remedial alternative affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. This ARAR would seem to favor the implementation of dry excavation, as this may have less impact. Coordination with state and federal agencies would be necessary to obtain the 401 and 404 permits, and to obtain water quality certifications to comply with these ARARs.

As required by the federal and state location-specific ARARs, any remediation activity (e.g., dredging or excavation) performed in wetlands, floodplains or coastal areas would be performed to mitigate adverse impacts on sensitive areas. Dredging or excavation of contaminated sediment, which by itself fulfills the goals of these regulations, would be limited to the extent necessary to achieve the cleanup objective. The Contractor would avoid wetlands and floodplains during the implementation of the remedial actions to prevent degradation of these areas. Other examples of control measures that would be taken include erosion control, flow restoration and treatment of any discharges.

The Fish and Wildlife Coordination Act requires that any appropriate agency exercising jurisdiction over a wildlife resource, and the U.S. Fish and Wildlife Service, be consulted before undertaking any acti that modifies a body of water. Special attention mu be given to the impact on wetlands and floodplai (lake shores) in accordance with Executive Orders 119 and 11888. In addition, the National Endanger Species Act requires that special attention be giv to the impact on areas where endangered species resid

VIN 002 0404

The sediments would be chemically fixated on-site. The requirements for the treatment activities are that the facilities would be constructed, operated and maintained according to RCRA facility standards, and according to OSHA Industry Standards and Regulations concerning hazardous wastes. RCRA 40 CFR 264 is applicable for these activities. RCRA 40 CFR 261.2(c)(1) and (d)(1) govern the degree of treatment applicable in regulating particulate air emissions from handling and transporting the fixated material for off-site disposal. Dust suppression measures would be provided for any potential fugitive dust pollution.

The liquid waste stream generated from the dredged sediments would be treated and discharged in compliance with the effluent requirements of the National Pollutant Discharge Elimination System (NPDES) and New Jersey State SPDES permit (NJAC 7:14A.2), as well as the New Jersey Surface Water Quality Standards.

The treated sediments would be transported off-site according to Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7).

The New Jersey Solid Waste Regulation (NJAC 7:26), particularly Subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfills (May 5, 1986) would be considered for managing treated nonhazardous wastes for off-site landfilling. This regulation would give guidance on classifying materials as ID 27 wastes.

As discussed in Subsection 3.1.1.2.2, it is assumed that the fixated material would meet delisting requirements, and would not be subject to RCRA LDRs.

Since arsenic-contaminated sediments would remain in the lake, CERCLA as amended would require that the site be reviewed every five years to determine the effectiveness of the alternative, or to identify new technologies that could be applied to the problems at this particular site.

At the start of the remedial design, a Stage IA Survey, consisting of a comprehensive literature search would be conducted according to the National Historic Preservation Act.

Based on the above analysis, it is expected that Alternative 2A would comply with the ARARs identified.

- **Overall Protection of Human Health and the Environment**: This alternative involves the removal and treatment of those sediments that were identified as a potential public health risk. Removal of these sediments would reduce the cancer risk level via the sediment ingestion exposure pathways to 2×10^{-6} in the more accessible areas. The cancer risk level in the less accessible areas would be reduced to 1×10^{-5}.

  Chemical fixation processes produce a solidified and stabilized matrix which results in a product that would be nonhazardous and subsequently meet delisting requirements. Chemical fixation would be a permanent and irreversible remedy for the contaminated sediments. It reduces the mobility of the arsenic compounds in the sediments.

  The remaining arsenic-contaminated sediments in the lake could pose a public health threat if the sediments are redistributed by natural transport mechanisms or human disturbance to the areas of remediation. These sediments would be accessible for human ingestion.

  Only a small percentage of arsenic contaminated sediment (approximately 5%) would be removed from the lake as a result of this alternative. Further reduction in the arsenic in the lake sediments, if desired, would have to be accomplished by natural processes. Due to the limitations of the available data, the mechanics of the lake are not fully known. There are two pathways for arsenic in the sediments to be removed by natural processes: arsenic desorption into the lake water and suspension of the arsenic-contaminated sediment into the lake water. In both of these pathways the arsenic could be transported out of the lake in the overflow. However, the arsenic desorption rate cannot be quantified utilizing the existing data. Furthermore, sediment transport/redeposition patterns within the lake are unknown. Therefore, while this alternative is protective of human health, the reduction of potential adverse environmental impacts as a result of this alternative cannot be quantified. It is believed that the implementation of this alternative may improve the lake ecosystem by reducing the potential exposure pathways of the arsenic contamination to fish and wildlife.

- **State Acceptance**: No specific comments to the fixation process were received; however, a comment concerning the location of the treatment facility was received. Due to the size of the lake and the remoteness of the areas to be remediated, the treatment facility would be relocated several times during the remediation. Therefore portable equipment and/or equipment that can be easily assembled and disassembled is preferred. The general comment concerning the implementation of the remedial alternative while the lake is at drawdown has been incorporated into the report. Also, additional sampling at the initiation of the remedial action to confirm the location of the sediments to be removed is applicable here.

o <u>Community Acceptance</u>: No public comments have been received to date.

4.2.3 <u>Alternative 2B</u> - <u>Removal/Fixation/On-Site Nonhazardous Landfill</u>

4.2.3.1 Description

The major features of this alternative include hydraulic dredging and chemical fixation of contaminated sediments, supernatant treatment and discharge, and on-site nonhazardous landfilling of the treated sediments. These activities would be the same as those discussed in Alternative 2A.

If the remediation is conducted when the lake is at drawdown, the major features of the alternative include dry excavation, chemical fixation of contaminated sediments, and on-site nonhazardous landfilling of the treated sediments. Excavation and fixation of the sediments would be the same as discussed in Alternative 2A.

This is a source control (removal and treatment) alternative, which is exactly the same as Alternative 2A except that the fixated sediments would be disposed of on-site. A schematic of the fixation system considering both hydraulic dredging of the sediments and excavation of the sediments is presented in Figure 4-1.

o <u>On-Site Nonhazardous Disposal</u>

The fixated sediment would be transported by trucks from the curing area to a landfill constructed on-site and disposed of there. The landfill would be situated in the southern section of the ViChem plant site. The ability to place the landfill on ViChem property has been facilitated by USEPA's definition of Union Lake as being part of the "Superfund Site".

The land area required for the landfill would be approximately 8 acres. Some of the area would be used for roads and maintenance facilities. The landfill would be constructed in accordance with the New Jersey Solid Waste Regulation (NJAC 7:26) requirements for nonhazardous sanitary landfills. The on-site landfill facility, depicted in Figure 4-4 and Figure 4-5 would contain a low permeability base and liner system, a leachate collection system and a three-layer capping system.

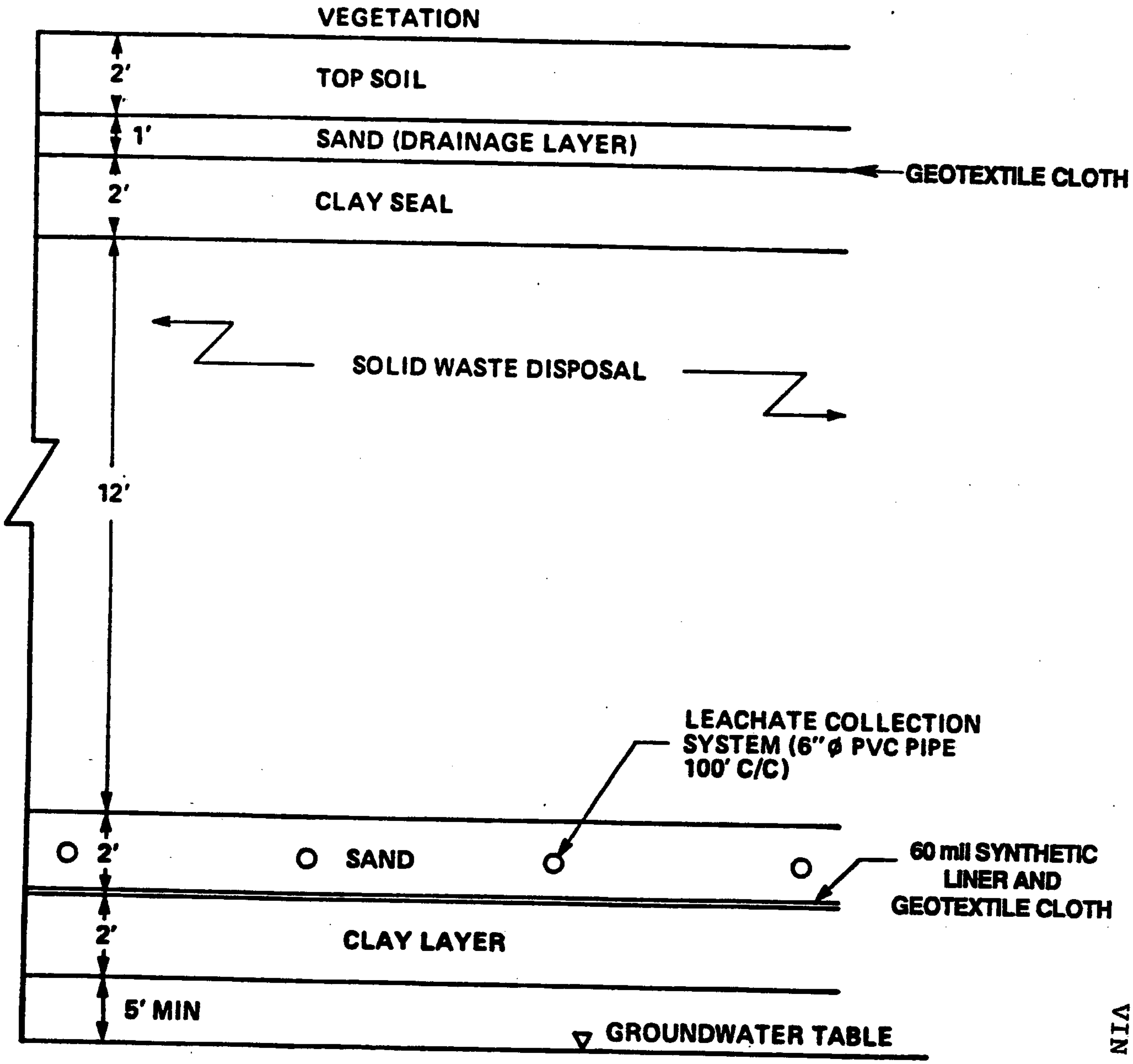
Two feet of clay, with a permeability less than 10^{-7} cm/sec, would be used as the landfill base. A synthetic liner of 40 mil high density polyethylene (HDPE) would be placed over the clay bed. The leachate collection system would consist of a two-foot thick sand layer and a network of six-inch diameter piping consisting of groups of perforated drainage pipe headed and backfilled with a gravel envelope. A layer of geotextile material would be placed on top of the sand to provide structural support while allowing filtration of leachate. Design considerations would include a base liner slope of two percent and pipe grades of 0.005 feet at a spacing of 100 feet. The leachate would be collected in a sump and trucked to the nearby industrial treatment plant for disposal.

The treated sediments would be deposited, graded, and compacted. After the completion of waste deposition, a three-layer capping system would be installed. The capping system would consist of a bottom clay layer, an intermediate drainage and geotextile layer, and a vegetation cover layer. The two-foot clay layer would be placed directly over the treated waste and would have a permeability of 10^{-7} cm/sec or less. A one-foot sand layer would be installed as a drainage layer and have a permeability greater than 1×10^{-3} cm/sec. Two feet of seeded topsoil would be placed on top of the sand layer to prevent erosion. As indicated in Alternative 2A, the total fixated sediment volume to be disposed of would be approximately 117,000 cubic yards.

A long-term, 30-year post closure groundwater monitoring program would be required to detect any leaching of contaminants from the fixated sediments. The groundwater monitoring system would include at least four monitoring wells, one upgradient and three downgradient of the landfill.

The major facilities and construction components for the on-site landfill are summarized in Table A-3 of Appendix A.

FIGURE 4-4
SCHEMATIC OF ON-SITE NON-HAZARDOUS LANDFILL



NOT TO SCALE

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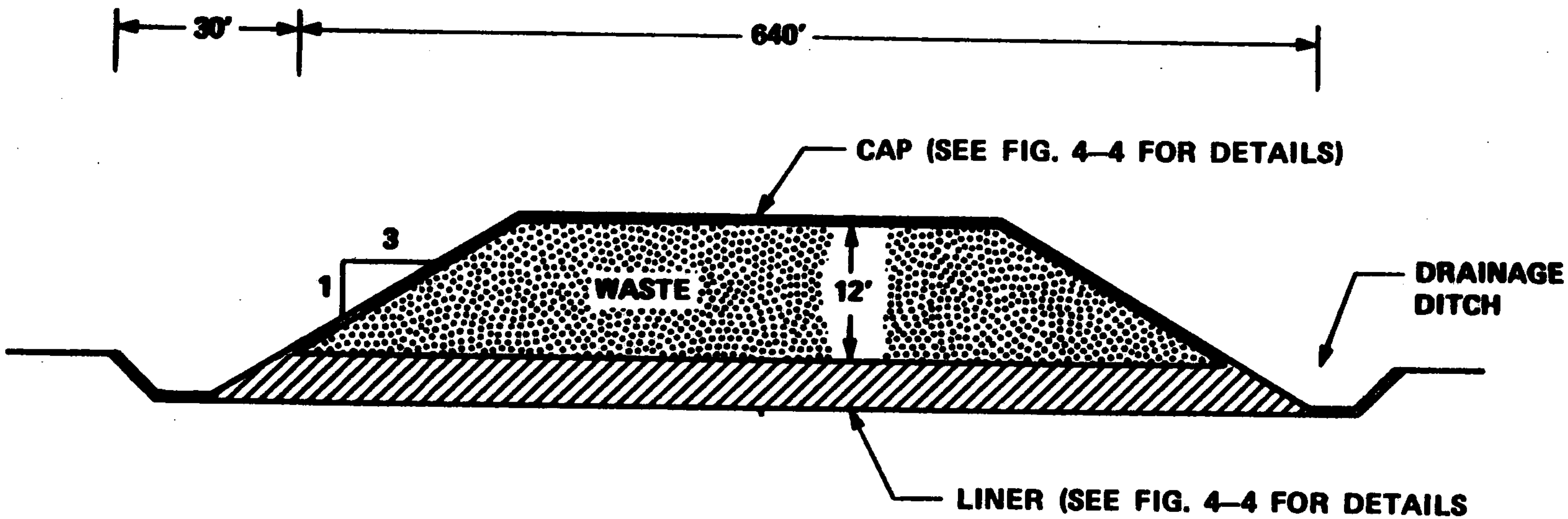
FIGURE 4-5
ON-SITE NON-HAZARDOUS LANDFILL LONGITUDIONAL CROSS SECTION



NOT TO SCALE

4.2.3.2 Assessment

- <u>Short-Term Effectiveness</u>: The short-term effectiveness of hydraulic dredging or excavation, and on-site chemical fixation would be identical to that presented for Alternative 2A described in Subsection 4.2.2.2. This alternative differs from Alternative 2A in that the fixated sediments would be disposed of in an on-site nonhazardous landfill facility. During construction of the landfill, workers would be properly protected against dermal contact and inhaling dust which would be generated during remedial action activities. The landfill activities would require local transportation and disposal, therefore adverse impacts on the environment resulting from traffic would be small. The nonhazardous landfill would be located at the ViChem plant site. The construction of the facility would have minimal impacts on public health and the environment.

  The time of completion is estimated to be three years. The short-term effects during the implementation can be minimized by utilizing appropriate protection and control measures.

- <u>Long-Term Effectiveness</u>: As with Alternative 2A, the removal and treatment of those arsenic-contaminated sediments identified as public health risks would reduce the baseline human health risks associated with ingestion of the arsenic sediments. A substantial quantity of arsenic would remain in the lake, which could be redistributed to the clean areas. Long-term monitoring would be required to measure the effectiveness of this alternative. Alternative 2B differs from Alternative 2A in that it utilizes a nonhazardous landfill constructed on-site for the disposal of fixated sediments. The main benefits associated with this alternative are the elimination of lengthy transportation to the off-site landfill facility and the associated costs.

  As discussed in Subsection 3.1.1.2.2, the fixated sediments would be expected to meet delisting requirements and would be considered nonhazardous. Such materials, even if disposed of in an unlined and uncapped landfill, would pose a very low threat of groundwater contamination.

  The landfill design would consist of a relatively impermeable base, synthetic liner, a cap, and a runoff collection and drainage system to meet the New Jersey Sanitary Landfill requirements. This design would assure that virtually no leachate would penetrate into the groundwater.

  The combination of chemical fixation and a lining would provide double protection against contaminant migration.

The proposed landfill on the ViChem plant site would not be located in an environmentally sensitive area. On-site landfilling of the fixated sediments would pose little risk to groundwater or surface water quality. This would be due to the low mobility of the fixated sediments and the effectiveness of the landfill system. A long-term management plan would be implemented to monitor the effectiveness of the landfill. In addition, institutional controls would be required to ensure that future uses of the area would not jeopardize the integrity of the landfill.

- <u>Reduction of Toxicity, Mobility, or Volume</u>: Alternative 2B entails hydraulic dredging or excavation depending on the lake condition at the initiation of the remediation, and chemical fixation, which would result in the same significant reduction of mobility of arsenic from the contaminated sediments as discussed in Alternative 2A. Chemical fixation processes do not detoxify directly, but do serve to contain contaminants in a matrix. The chemical fixation process would result in an increase in the volume and weight of material after treatment is complete.

  As previously stated, this alternative differs from Alternative 2A described in Subsection 4.2.2 only in that the fixated sediments would be disposed of on-site in a nonhazardous landfill. The disposal of fixated sediment in a nonhazardous landfill would further reduce the mobility of contaminants through containment. The combination of fixation/solidification and a lining system in a landfill would provide double protection against the leaching of contaminants into groundwater. On-site landfilling would differ from off-site landfilling in that it would not completely remove the potential source of contamination from the site. The future use of the landfilled areas would be limited to minimize disturbances to the waste cells.

<u>Implementability</u>

- <u>Technical Feasibility</u>: As discussed in Alternative 2A, sediment fixation is a well established process, particularly for inorganic contaminants. It is very reliable, as proven through bench-scale testing. The fixated product would be an impermeable nonhazardous mass with structural stability that could withstand wet-dry and freeze-thaw weather conditions. Under this alternative, the landfill would effectively contain the wastes, as long as it is properly constructed and regularly maintained.

  The primary limiting factor regarding the implementation of this alternative would be the delisting of the treated sediment. Treatability results and discussions with the fixation vendor have indicated that treating sediments to

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obtain EP Toxicity leachate arsenic concentrations below 0.32 mg/l, established by the VHS model, would be technically feasible. The fixated material is expected to achieve a leachate concentration of 0.32 mg/l arsenic, thus meeting the substantive delisting requirement.

The availability of land at the ViChem site would not be expected to pose a significant problem. The construction of a nonhazardous landfill would not be complex, but would require a substantial on-site construction effort with conventional heavy equipment. It would not pose a constructibility or technology problem.

The time to complete remediation would be approximately 24 months. Contractors and equipment would be readily available. The time required to construct the landfill would take approximately six months. The major drawback would be the uncertain lifespan of the synthetic liners which would be very difficult to replace.

- <u>Administrative Feasibility</u>: Since the landfill would be located on-site, a delisting petition to NJDEP would not be necessary. Rather, according to USEPA Headquarters personnel, the Regional Administrator in USEPA's Region II could authorize nonhazardous disposal, providing that the delisting requirements were met. The delisting authorization would have to be arrived at in conjunction with the NJDEP Division of Waste Management, which would regulate the classification of the treated materials as ID 27 waste.

  On-site landfilling of fixated sediments would require appreciable administrative efforts to coordinate with state and local agencies to negotiate and secure an agreement on land acquisition. The ViChem plant site is in a partly residential area, therefore considerable administrative effort may be required to obtain local public approval for siting a landfill there. Implementability of an on-site nonhazardous landfill would entail efforts to ensure proper design and construction. Long-term administrative management would be necessary to monitor the landfill and the underlying groundwater, as well as to perform five-year reviews. To ensure adequate containment of wastes, long-term maintenance would also be required.

- <u>Cost</u>: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at drawdown. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-3, is estimated to be $13,742,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table B-11, are approximately $20,562,000 and $90,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $51,414,000. This represents all of the activities to dredge, thicken, fixate, haul and landfill the sediments and to treat the contaminated supernatant; to perform all operation and maintenance functions on the treatment system components and the on-site nonhazardous landfill; to perform annual monitoring to assess sediment redistribution; and to perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at its full condition were $85,772,000 and $139,239,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +67% to 171% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-3 and graphically represented in Figure 4-2.

The capital cost for this alternative with the lake at drawdown, as outlined in Table C-2, is estimated to be $11,467,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table C-9, are approximately $20,487,000 and $90,000, respectively. The present worth costs, calculated at a discount rate of 5% after inflation, is $49,006,000. This represents all of the activities to excavate, fixate, haul and landfill the contaminated sediments; to perform all operation and maintenance functions on the treatment system components and the on-site nonhazardous landfill; to perform annual monitoring to assess sediment redistribution; and to perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at draw-down condition were $81,797,000 and $132,945,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +67% to 171% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-4 and graphically depicted in Figure 4-3.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth cost of the alternative, assuming no disposal costs or operation and maintenance costs associated with the disposal, is $44,293,000 and $41,886,000 for the lake at its full condition and the lake at drawdown, respectively.

In the event that the treated sediments cannot be considered delistable, off-site RCRA hazardous landfilling would be required. The present worth costs for this alternative considering RCRA disposal of the treated sediments when the lake is at its full condition and when the lake is drawn down are $52,013,000 and $49,382,000, respectively.

o <u>Compliance with ARARs</u>: The same ARARs that apply to the hydraulic dredging and excavation, chemical fixation and supernatant treatment/discharge activities discussed for Alternative 2A are applicable for this alternative. These ARARs and regulations include RCRA and OSHA requirements, as well as New Jersey Surface Water Quality Standards and New Jersey Solid Waste Regulations.

This alternative also includes on-site nonhazardous landfilling of treated sediments. Chemical fixation of sediments posing human health risks would immobilize arsenic to levels compatible with delisting criteria. Requirements of RCRA LDRs would be waived after the sediments are treated and delisted. Landfilling of the treated sediments would result if the NJDEP classified them as ID 27 waste.

The New Jersey Solid Waste Regulations (NJAC 7:26) Subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfill (May 5, 1986) would regulate the design of the on-site nonhazardous landfill facility. The on-site nonhazardous landfill facility would consist of a liner system, a leachate collection and treatment system, a surface drainage system and erosion control, and a surface capping system in accordance with the requirements of Subchapter 7:26-2A-4, General Prohibitions and Requirements. These regulatory requirements and standards were established for the design and construction of landfills to ensure that adverse impacts are minimized and controlled, and the pollution of the environment is prevented.

At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be conducted according to the National Historic Preservation Act.

Based on this analysis, Alternative 2B would be expected to comply with all ARARs identified.

- Overall Protection of Human Health and the Environment: The evaluation of overall protection of human health and the environment discussed in Alternative 2A is applicable for this alternative, except in this alternative the treated sediments would be disposed of in an on-site nonhazardous landfill. Chemical fixation of the contaminated sediments would immobilize arsenic compounds, thus minimizing leaching from the sediments and further exposure to human receptors and the environment. As discussed in Alternative 2A, the public health risk would be reduced to the target level of 2×10^{-6} in the more accessible areas, and 1×10^{-5} in the less accessible areas. Contaminated sediments would remain on-site and future redeposition of these sediments in areas where human ingestion could be possible could cause the future cancer risk to exceed the target.

  The on-site nonhazardous landfill facility would be constructed at the ViChem plant site. The proposed site is not in a sensitive ecosystem area. The fixated sediments would be nonhazardous such that disposal in an on-site landfill facility would pose very little risk to groundwater and surface water quality. Even if such materials were disposed of in unlined and uncapped landfills, the threat of groundwater and surface water contamination would be considered relatively low. This is largely due to the low mobility of fixated sediments and the effectiveness of the landfill facility.

- State Acceptance: State comments were not directed at the actual fixation treatment process. General comments were given towards considering the remediation to be conducted with the lake at its full condition and with the lake at drawdown. This has been addressed in the text. In addition, other comments included concern toward additional sediment and water sampling prior to the initiation of remediation at the lake to better define the limits of contamination. The alternatives have been modified to include this additional sampling.

- Community Acceptance: No public comments have been received to date.

4.2.4 Alternative 3A - Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

4.2.4.1 Description

The major features of this alternative include hydraulic dredging or dry excavation of contaminated sediments, two-stage sediment

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water extraction treatment and disposal, extractant water treatment and discharge, and hazardous sludge disposal. A two-stage water extraction process and associated wastewater treatment system would be utilized to remove the arsenic from the sediments. A schematic flow diagram is shown in Figure 4-6 presenting the extraction system for both dredged sediments and excavated sediments. This is a source control (removal/treatment) alternative in which the contaminated sediments would be removed and the arsenic would be extracted from the sediments. The highly contaminated arsenic sludge generated by the extraction process would be treated and disposed of by a vendor at an off-site RCRA hazardous waste facility. The processed sediments would be disposed of in an off-site nonhazardous landfill facility as discussed in Alternative 2A.

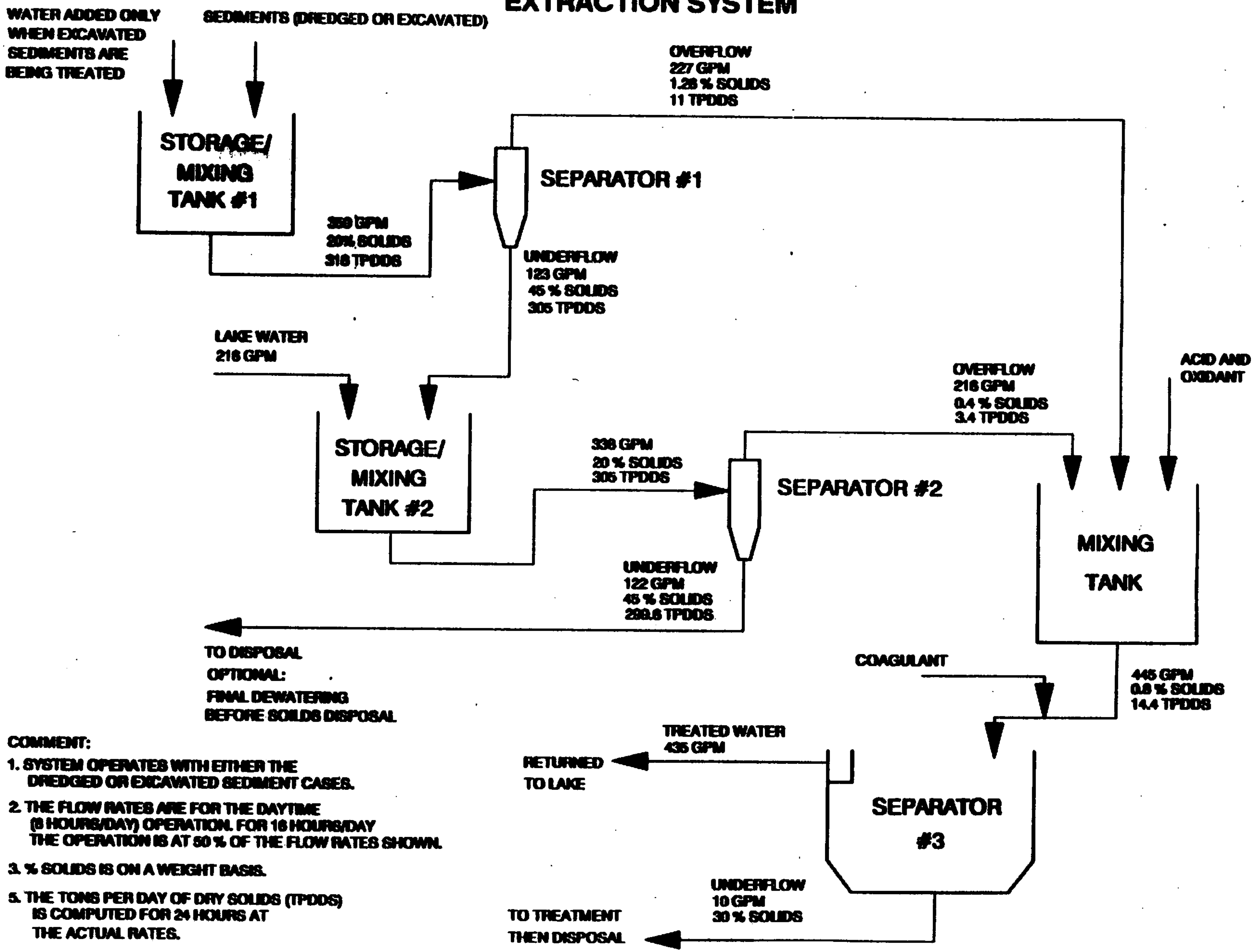
- <u>Sediment Water Extraction and Wastewater Treatment</u>

  The in-place sediment is approximately 54% solids. The dredging operation would draw lake water into the sediment so that a slurry of approximately 20% solids would be pumped into a mixing vessel (actually 2 mixers in parallel with a 2-hour retention time for each mixer). If the remediation were conducted when the lake is at drawdown, the sediments would be excavated. The excavated sediments would be combined with water from the lake to produce a 20% solid slurry in the mixing vessel (actually 2 mixers in parallel, with a two-hour retention time for each mixer). A separate feed line of lake water, operating on density control, would add water to the mixer so that the maximum solids concentration would not exceed 20%.

  The slurry would be pumped to a bank of 14 six-inch diameter hydroclones mounted in parallel. Seven hydroclones would be operating and seven would be standby units. An underflow of 45% solids would discharge into a second mixer (actually two mixers in parallel); the overflow would go to an extractant water treatment system. Lake water would be pumped into the second set of mixers, under density control, to maintain a slurry of 20% solids. The slurry would then be pumped to a second bank of 14 hydroclones (seven operating and seven standby). The residual arsenic in the underflow solids would be a maximum of 10% of the original amount of arsenic present in the sediment. The underflow would then go to final dewatering. The dewatered sediment would then be disposed of as nonhazardous material.

  The overflow from the second bank of hydroclones would go to the same extractant water treatment system as the overflow from the first bank of hydroclones.

FIGURE 4-6
EXTRACTION SYSTEM



COMMENT:

1. SYSTEM OPERATES WITH EITHER THE DREDGED OR EXCAVATED SEDIMENT CASES.
2. THE FLOW RATES ARE FOR THE DAYTIME (8 HOURS/DAY) OPERATION. FOR 16 HOURS/DAY THE OPERATION IS AT 50 % OF THE FLOW RATES SHOWN.
3. % SOLIDS IS ON A WEIGHT BASIS.
5. THE TONS PER DAY OF DRY SOLIDS (TPDDS) IS COMPUTED FOR 24 HOURS AT THE ACTUAL RATES.

The overflow streams from the hydroclones would be discharged to a reactor tank. Any soluble arsenic would be in the form of As_2O_3, which is soluble in water. The As_2O_3 would be oxidized with potassium permanganate to As_2O_5, which is insoluble in water and would precipitate out of solution. The reaction is:

$$5\ As_2O_3 + 4\ MnO_4^- + 12H^+ = 5\ As_2O_5 + 4\ Mn^{++} + 6\ H_2O$$

The reaction requires a low pH of 2.0, therefore hydrochloric acid would be added ahead of the permanganate.

The liquid solids mixture would flow to a clarifier, where the liquid pH would be raised to 6.5 with the addition of sodium hydroxide (NaOH) or lime ($Ca(OH)_2$). Ferric chloride ($FeCl_3$) would be added to coagulate the arsenate, manganate and manganese dioxide precipitate into larger and denser particles to facilitate settling. A liquid polymer would also be added to aid in the flocculation of the large particles.

The effluent from the clarifier would be discharged back to the lake after arsenic concentrations are reduced below the 0.05 mg/l MCL. A portion of the water would be used as a wash water later in the extraction process.

o <u>Off-Site Hazardous Sludge Disposal</u>

Sludges generated from the clarifier would contain settled solids, metallic and organic arsenic, and other residues from the treatment process in a concentrated form. This sludge would be hauled off-site by a licensed vendor to a disposal facility where treatment could incorporate any number of viable technologies (for the purpose of this report it is assumed that fixation would be used). RCRA landfilling would take place once land disposal standards are obtained from the treatment process (assumed to be a treatability variance of 1 mg/l arsenic in the EP Toxicity extract from the treated sludge).

The major construction components and facilities for this alternative are outlined in Table A-4 of Appendix A.

4.2.4.2 Assessment

o <u>Short-Term Effectiveness</u>: The short-term effectiveness concerns with this extraction alternative include public health threats, the safety of workers during the implementation activities, and adverse impacts on the environment.

If remediation is conducted with the lake at its full condition, dredging would be the method of sediment removal. The hydraulic dredging operations would pose similar adverse environmental effects as those discussed in Alternative 2A. However, as the dredging would be limited to local shallow water areas, suspensions would settle in a short amount of time. The utilization of silt curtains would further minimize any disturbances to the area. The adverse effects on the lake ecosystem and the environment would be temporary and localized.

The risk to the community and to the workers generated during the excavation activities, if the remediation is conducted when the lake is at drawdown, are similar to those discussed in Alternative 2A (Subsection 4.2.2.2). Adequate dust suppression measures and protection equipment for personnel would be provided to minimize the risks of inhalation of and direct contact with the contaminated sediment.

The on-site risk to worker safety would be slightly higher for the extraction and extractant treatment than for the chemical fixation, discussed in Alternative 2A, due to the greater number of treatment processes required for this alternative. The extractant treatment system would utilize liquid chemicals, which may be spilled. However, substantial measures to prevent spillage, and proper personnel protective equipment would be provided to workers to prevent direct contact with wastes and chemicals. As stated in Alternative 2A, the short-term risks to workers would be minimal for this alternative.

This alternative would require adequate land space to lay out the treatment process. Potential worker safety and environmental threats would be associated with pipe leaks, spills or accidental releases of the extractant. These threats could be minimized by utilizing preventative measures and standardized industrial construction procedures.

The short-term impacts on the environment, such as traffic problems and associated noise and air pollution, for this alternative would be similar to those presented in Alternative 2A. An appropriate local traffic control plan would be implemented to minimize these short-term environmental impacts.

The time required to complete this remedial action is estimated to be three years. Any short-term effects could be minimized by utilizing adequate preventative measures and proper personnel protection equipment.

- **Long-Term Effectiveness**: Extraction methods are designed to remove arsenic compounds from the contaminated sediments, thus attaining reductions in the toxicity and mobility of the waste. The removal of the contaminated sediments would minimize public health threats. The treated sediments would contain total arsenic below the action level of 20 mg/kg. The treated sediments would not be expected to leach arsenic above 0.32 mg/l (VHS model delisting criteria) which would serve as the basis for delisting the sediments. The extractant separated from the sediment would be treated to remove arsenic to below the target level of 0.05 mg/l prior to discharge. The extractant sludge, after treatment, is not expected to pass the 0.32 mg/l criteria for delisting, but is expected to pass the 1 mg/l treatability variance criterion, allowing for its disposal in a hazardous waste landfill. This alternative provides a permanent remedy for the contaminated sediments identified as a public health risk.

  As with Alternative 2A, the major benefits associated with this alternative would be the remediation of contaminated sediments, using water washing as opposed to fixation. The cancer risks from arsenic via the exposure pathways of direct contact and the ingestion of sediment would be reduced to the target level of 2×10^{-6} in the more accessible areas, and 1×10^{-5} in the less accessible areas. However, only approximately 5% of the arsenic contaminated sediment would be removed from the lake. Long-term effects could be significant if the arsenic redistributes to the remediated areas due to natural transport mechanisms or human disturbance. If this occurs, additional remedial activities would be required. Therefore, a long-term monitoring program, specified for Alternative 2A, would also be required for this alternative to measure the effectiveness of this alternative.

  The technology for this alternative would be expected to sufficiently reduce the level of arsenic contamination in the sediments to meet the delisting criteria. The treated sediments would be deposited in a nonhazardous landfill facility and the treated extractant would be discharged to Union Lake with minimal adverse impact to the environment.

- **Reduction of Toxicity, Mobility, or Volume**: This alternative would reduce the toxicity of contaminants in the lake by removing and treating the sediments identified as a public health risk. Removing contaminated sediments from the lake would minimize the mobility of the contaminants. Reducing the toxicity would be achieved by extracting the arsenic from the sediments by utilizing a two stage washing process with water. Results from bench-scale treatability studies (see ViChem RI Section 6.0) indicated that a single stage extraction with water could drastically reduce the sediment arsenic concentration.

A two-stage wash was used in this FS to provide for even further extraction potential. It is assumed that the washed sediments would pass the VHS model EP Toxicity leaching criterion of 0.32 mg/l. Subsequent chemical oxidation and physicochemical precipitation would reduce the toxicity of the arsenic and would remove it from the liquid extractant. The combination of both sediment and wastewater treatment would greatly reduce the toxicity and volume of the contaminant. Disposing of the treated sediments in an off-site landfill and disposing of the sludge containing the arsenic in a RCRA treatment and disposal facility would further reduce the mobility of the former on-site contaminants, and would reduce the volume of contaminants remaining on-site.

<u>Implementability</u>

- <u>Technical Feasibility</u>: As stated in Alternative 2A, (Subsection 4.2.2.2) hydraulic dredging or excavation, extractant water treatment and disposal of treated sediments in an off-site landfill facility are all well-developed technologies that are commercially available. Equipment necessary for implementing these technologies would also be readily available. These technologies are highly feasible, reliable, and are expected to be available for the site.

  The water extraction process would be a reliable technology that would meet the designated process efficiencies and performance goals. It would be unlikely that any unusual technical difficulties would arise. Labor and materials would be readily available for all components of this alternative. The relatively complex components of this alternative would be sediment extraction and extractant treatment, which are proven technologies. The other components would be comparatively simple. There would be no major treatment difficulties that are expected during the implementation of this alternative, based on the following considerations:

  - Mud Cat dredges have been successfully used in various shallow water hydraulic dredging operations. Resuspension of sediments in the lake environment can be minimized by increasing the water content of the influent stream.

  - Excavation is a standard operation that is reliable and available.

  - Water extraction is a conventional industrial process. Treatability studies demonstrated that a single stage water wash could extract arsenic from sediments to approximately 34 mg/kg. A two-stage wash would provide further arsenic removal.

- EP Toxicity results for arsenic in untreated sediment samples yielded results below 0.32 mg/l, the substantive requirement for delisting the treated wastes.

- Chemical oxidation and coagulation/flocculation/precipitation with $FeCl_3$ are both traditional wastewater treatment technologies for removing arsenic and organics.

More than one vendor or manufacturer would be capable of providing a competitive bid for each component of this alternative. Several vendors would be able to supply turnkey services for disposal of the hazardous treatment sludges. It is estimated that approximately 36 months would be required to implement this alternative. The time to achieve beneficial results would follow the implementation of a successful groundwater management of migration program at the ViChem facility, and dredging and excavation of contaminated river sediments.

- <u>Administrative Feasibility</u>: The treated extractant waste streams would be returned to Union Lake. A discharge permit would not be required since this would represent an on-site Superfund discharge. However, a demonstration that these discharges would be in compliance with ARARs would be required for State and local approvals. Since the supernatant would be treated to meet New Jersey Surface Water Quality Standards and NJPDES requirements, State and local approvals should not pose a problem. The treated extractant waste stream would contain total arsenic below the State's discharge limit (i.e., 0.05 mg/l).

  In order to operate and maintain this complex treatment system, an operation and maintenance program would be required. Institutional administration would be required to secure a nearby nonhazardous landfill site for the disposal of the extracted sediments. Since the treated sediment is expected to be delisted by NJDEP as nonhazardous, it can be disposed of at a nonhazardous landfill after an ID 27 waste classification is given by the NJDEP. Delisting would require a petition and may require considerable time and effort to accomplish. Arranging for the treatment and disposal of hazardous sludges at an RCRA treatment/disposal facility would require administrative effort. The growing number of licensed multiservice waste handling vendors should aid in the manageability of this remediation aspect. Annual site monitoring and five-year reviews demand long-term administrative attention. In addition, coordination with local traffic authorities would be required to control the additional traffic involved with transporting the treated sediments to the nonhazardous landfill. An appropriate local traffic control plan and air pollution control measures such as dust suppression would be implemented.

o Cost: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at drawdown. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-4, is estimated to be $25,740,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table B-12, are approximately $1,832,000 and $13,020, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $29,227,000. This represents all of the activities to dredge, extract with water, haul and landfill the sediments and to treat the contaminated extractant; to haul and landfill the hazardous sludges; to perform all operation and maintenance functions on the treatment system components; to perform annual monitoring to assess sediment redistribution; and to perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at its full condition were $45,402,000 and $70,633,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +55% to +142% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-3 and are graphically represented in Figure 4-2.

The capital cost for this alternative with the lake at drawdown, as outlined in Table C-3, is estimated to be $23,973,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table C-10, are approximately $1,808,000 and $13,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation is $27,417,000. This represents all of the activities to excavate, extract with water, haul and landfill the sediments and to treat the contaminated extractant; to haul and landfill the hazardous sludge; to perform all operation and maintenance functions on the treatment system components; to perform annual monitoring to assess sediment redistribution; and to perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at draw down condition were $42,085,000 and $64,965,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +53% to +137% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-4 and are graphically depicted in Figure 4-3.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth costs of the alternative, assuming no disposal costs, are $15,787,000 and $13,977,000 for the lake at its full condition and the lake at drawdown, respectively.

In the event that the treated sediments cannot be considered delistable, off-site RCRA landfilling would be required. The present worth costs for this alternative considering RCRA disposal of the treated sediments when the lake is at its full condition and when the lake is drawn down are $46,538,000 and $44,269,000, respectively.

- <u>Compliance with ARARs</u>: The discussion on the compliance with ARARs in Alternative 2A in Subsection 4.2.2.2 is applicable for this alternative as well. The only items in Alternative 3A that differ from Alternative 2A are the off-site RCRA treatment and disposal of the arsenic-contaminated sludge generated from the extraction process and the additional effluent discharge to Union Lake generated from the extractant treatment system. The evaluation of Alternative 3A with respect to compliance with ARARs is summarized as follows:

  - Appropriate preventive measures would be provided to minimize resuspension, erosion and dissolved oxygen depletion during hydraulic dredging, and to minimize erosion during excavation in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10.

  - Hydraulic dredging would avoid the wetland areas where possible, and wetland restoration would be implemented for the disturbed areas in order to comply with Sections 401 and 404 of the CWA identified in Alternative 2A.

  - Excavation would also avoid the wetland areas where possible, and wetlands restoration would be implemented for the disturbed areas. As excavation allows more control of operations than hydraulic dredging,

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excavation would be the favored means of sediment removal relative to Section 404 of the CWA identified in Alternative 2A.

- The extraction processes would be performed in order to convert the contaminated sediments into nonhazardous wastes in accordance with RCRA 40 CFR 261.2 requirements.

- The installation and operation of the two-stage extraction system and the extractant and supernatant treatment system, would comply with RCRA 40 CFR 264 Standards for Owners and Operators of Hazardous Waste Treatment Facilities.

- The extractant waste water would be treated in compliance with the effluent requirements of Federal Clean Water Act Quality Criteria, New Jersey Surface Water Quality Standards and NJPDES Discharge to Surface Water Requirements.

- The Clean Air Act and National Air Quality Standards would be complied with for particulate air emissions resulting from the handling and transporting of the extracted materials to an off-site disposal facility.

- Disposal of delisted treated sediments at a nonhazardous landfill facility and treatment/disposal of the arsenic contaminated sludge at a RCRA facility would comply with RCRA LDRs.

- DOT Rules for the Transportation of Hazardous Materials (40 CFR 100-177) would be complied with for transport of the arsenic-contaminated sludge to a RCRA treatment and disposal facility.

- Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7) would be complied with for the transport of the treated sediments to a nonhazardous landfill.

- New Jersey Solid Waste Regulations (NJAC 7:26) would be used to verify that existing sanitary landfill facilities could safely dispose of the treated sediment.

- At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be conducted according to the National Historic Preservation Act.

Based upon the above analyses and assumptions, Alternative 3A is expected to meet all applicable ARARs and TBCs.

- **Overall Protection of Human Health and the Environment**: This alternative would have the same overall protection of human health and the environment as discussed in Alternative 2A. Removal of the contaminated sediments would achieve a reduction in the risks to public health due to sediment ingestion in the shallow areas of the lake where the sediment arsenic concentration exceeds the target cleanup levels. Extraction would remove arsenic compounds from the contaminated sediments and would result in a reduction of the toxicity of the sediments and the volume of contaminants in the sediments. Off-site disposal of the treated sediments and the sludge containing the arsenic would further reduce the volume of contaminants remaining on-site.

  As with Alternative 2A, this removal and treatment alternative would reduce the existing cancer risk level in the more accessible areas of the lake to the target of 2×10^{-6}. The cancer risk would be reduced to 1×10^{-5} in the less accessible areas of the lake. After implementing this alternative, and after implementing a successful management of migration alternative for the groundwater at the ViChem facility, the public health risks from the lake areas would be reduced.

  Long-term monitoring would be required to assess the arsenic inventory in the lake and the redistribution pattern of the sediments.

  As discussed in Alternative 2A, the reduction of potential adverse environmental impacts as a result of this alternative cannot be quantified due to the limited available data.

- **State Acceptance**: The previous comment concerning sediment sampling prior to the initiation of the remedial activity to confirm the location of the sediments to be removed and inclusion of the provision that the remediation may be conducted with the lake at drawdown condition are applicable to this alternative.

- **Community Acceptance**: No public comments have been received to date.

4.2.5 Alternative 3B - Removal/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

4.2.5.1 Description

The major features of this alternative include hydraulic dredging or excavation of contaminated sediments; water extraction of the dewatered sediments; on-site extractant treatment; on-site nonhazardous landfilling of the treated sediments; and off-site hazardous disposal of treatment sludges. This is a source control (removal and treatment) alternative and is exactly the same as Alternative 3A, except that the treated sediments would be disposed of on-site. The on-site nonhazardous landfill for this alternative is similar to Alternative 2B except the landfill area would be slightly smaller. It is estimated that the treated sediments from this alternative would occupy a volume of approximately 71,000 cubic yards and would require approximately five acres of land. A long-term monitoring program would be required.

4.2.5.2 Assessment

- <u>Short-Term Effectiveness</u>: Short-term effectiveness for Alternative 3B is the same as for Alternative 3A (Subsection 4.2.4.2), except that in this alternative the extracted sediments would be disposed of in an on-site nonhazardous landfill facility. On-site workers would potentially be exposed to contaminants by dermal contact and by dust inhalation during hydraulic dredging or excavation, extraction and sediment transfer to the landfill facility. To minimize or prevent such exposure, dust control measures and personnel protection equipment would be used. The treated sediment would be transported via truck over a short distance to the on-site landfill at the ViChem plant site. The adverse impacts on the environment during the remedial alternative would be temporary and minimal. The time required to complete this remedial action and to achieve protection is approximately three years.

- <u>Long-Term Effectiveness</u>: Alternative 3B has the same long-term beneficial effectiveness as Alternative 3A. There are expected to be minimal adverse environmental impacts resulting from installing an on-site nonhazardous landfill at the ViChem plant site.

  An on-site nonhazardous landfill would require long-term administrative management, including facility maintenance and groundwater monitoring. A secondary waste management program would be required to handle the potential leachate from the remaining arsenic compounds in the treated wastes.

  As discussed in Alternative 3A, this alternative would remove and treat those sediments identified as a potential public health risk. This action would reduce the cancer risk level via the sediment ingestion exposure pathway to 2×10^{-6} in the more accessible areas of the lake, and 1×10^{-5} in the less accessible areas. Long-term monitoring would be required to measure the effectiveness of this alternative and the redistribution patterns of the sediment in the lake.

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o **Reduction of Toxicity, Mobility or Volume**: The removal and treatment of the contaminated sediments would reduce the existing arsenic loads from the lake areas that pose the greatest health risks and would also slightly reduce the potential migration of arsenic contaminants from sediments to surface water and regions downstream of Union Lake. The two-stage water extraction process would extract arsenic from the contaminated sediments to below the target level of 20 mg/kg. Alternative 3B would result in a significant reduction in toxicity and volume of arsenic in the contaminated sediments. The mobility of the remaining arsenic in the treated sediments would be reduced because the sediments would be contained in a landfill. Alternative 3B would yield the same results as Alternative 3A, except the nonhazardous landfill would be located on-site.

o **Implementability**

Technical Feasibility: The technical feasibility of hydraulic dredging or excavation of the contaminated sediments, two-stage extraction, supernatant water treatment and extractant treatment presented in Alternative 3A is identical to that of Alternative 3B. These technologies are considered highly feasible and reliable, and are expected to be available. The implementation of this remedial alternative would require approximately two years for construction, operation and maintenance. There are no major treatment difficulties expected to occur during the implementation of this alternative.

The construction of a nonhazardous landfill facility is a simple task that utilizes normal construction equipment. The only technical difficulty for the landfill facility maintenance would be the repair of the bottom synthetic liner. However, a well maintained capping system would minimize rainfall infiltration, which would prolong the useful lifetime of the synthetic membrane.

The disposal of treatment sludges would be facilitated by a licensed vendor having available treatment and landfill facilities.

Administrative Feasibility: As with Alternative 2B, an on-site landfill would require more administrative efforts than an off-site landfill. An on-site landfill would require the following institutional involvement:

o Coordination with State and local governments and the owner of the ViChem property to negotiate and secure an agreement on land acquisition;

- Review supervision and management to ensure proper design and construction of an on-site landfill facility; and

- A long-term administrative management program for landfill maintenance, leachate collection and disposal, and groundwater monitoring.

Additional administrative efforts would be required of the USEPA Region II Regional Administrator to authorize nonhazardous disposal of the extracted sediments providing that the delisting requirements are met. However, it would not be necessary to file a delisting petition to the NJDEP, which would ease administrative efforts somewhat. Classification of the treated sediments as ID 27 waste would have to be made by NJDEP. Five-year reviews of the landfill and annual reviews of the lake would be required. These institutional requirements are considered to be feasible.

- Cost: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at draw down. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-5, is estimated to be $16,017,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table B-13, are approximately $1,832,000 and $60,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $20,133,000. This represents all of the activities to dredge, extract with water, and landfill the sediments and to treat the contaminated extractant; to haul, treat, and landfill the hazardous sludges; to perform all operation and maintenance functions on the treatment system components and the on-site nonhazardous landfill; to perform annual monitoring to assess sediment redistribution; and to perform the six required five-year reviews.

  A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at its full condition were $29,214,000 and $43,379,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +45% to +115% over the estimated present worth cost of the base case alternative. The costs are summarized in Table 4-3 and graphically represented in Figure 4-2.

The capital cost for this alternative with the lake at draw down, as outlined in Table C-4, is estimated to be $14,249,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table C-11, are approximately $1,808,000 and $60,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation is $18,323,000. This represents all of the activities to excavate, extract with water, and landfill the sediments and to treat the contaminated extractant; to haul and landfill the hazardous sludge; to perform all operation and maintenance functions on the treatment system components and the on-site nonhazardous landfill; to perform annual monitoring to assess sediment redistribution; and to perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at draw down condition were $25,897,000 to $37,711,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +41% to +106 over the estimated present worth cost of the alternative. The costs are summarized in Table 4-4 and graphically presented in Figure 4-3.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth costs of the alternative, assuming no disposal costs or operation and maintenance costs associated with the disposal, are $15,614,000 and $13,804,000 for the lake at its full condition and the lake at drawdown, respectively.

In the event that the treated sediments cannot be considered delistable, off-site RCRA landfilling would be required. The present worth costs for this alternative considering RCRA disposal of the treated sediments when the lake is at its full condition and when the lake is drawn down are $20,654,000 and $18,276,000, respectively.

- <u>Compliance with ARARs</u>: Alternative 3B would comply with those ARARs discussed in Alternative 3A. In addition, the New Jersey Solid Waste Regulations (NJAC 7:26) Chapter 2A - Additional Specific Disposal Regulations for Sanitary Landfills, would be used as the basis for the design, operation, closure, and monitoring plans of the on-site nonhazardous landfill. Based on this analysis, Alternative 3B is expected to comply with all ARARs identified.

- <u>Overall Protection of Human Health and the Environment</u>: Alternative 3B would provide the same overall protection of human health and the environment as discussed in Alternative 3A, Section 4.2.4.2. The beneficial impacts would include reducing the sediment ingestion related cancer risk level in the lake to 2×10^{-6} and 1×10^{-5} in the more accessible areas of the lake and in the less accessible areas of the lake, respectively, assuming the most plausible sediment exposure pathway models. In addition, the implementation of this alternative may improve the lacustrine ecosystem by reducing the potential exposure pathways of the arsenic contaminants to the fish and wildlife. Long-term monitoring would be required to survey the redistribution patterns in the lake.

  This alternative would dispose of the treated sediments in a nonhazardous landfill facility built at the ViChem plant site. The sediments would be nonhazardous such that their disposal in an on-site landfill facility would pose very little risk to groundwater and surface water quality. Even if such materials were disposed of in an unlined and uncapped landfill the threat of groundwater and surface water contamination would be considered relatively low. This is largely due to the low level of contamination and leachability of the extracted sediments and the effectiveness of the landfill facility. This alternative would provide adequate protection to public health and the environment and it would reduce somewhat the existing toxicity, mobility and volume of arsenic contaminants in the lake sediments.

- <u>State Acceptance</u>: The same comments mentioned previously concerning the need for sampling prior to the initiation of the remedial action and the consideration of remediation occurring when the lake is at drawdown condition are applicable here.

- <u>Community Acceptance</u>: No public comments have been received to date.

4.2.6 Alternative 3C - Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal

4.2.6.1 Description

The major features of this alternative include hydraulic dredging or excavation of contaminated sediments, two-stage water extraction of the dewatered sediments, supernatant water treatment and extractant treatment with discharge to Union Lake, uniform deposition of treated sediments in previously dredged/excavated areas of Union Lake, and off-site hazardous disposal of treatment sludges. This is a source control (removal and treatment) alternative and is exactly the same as Alternatives 3A and 3B except that the treated sediments would be disposed of in Union Lake.

- Lake Deposition

  The treated sediments would be transported by barges equipped with pneumatic pumps or by trucks to the remediation areas of Union Lake. The sediments would be pumped or manually deposited and allowed to settle uniformly over the lake bottom. If necessary, grading of the treated sediments would be implemented to maintain the original contours of the lake.

  If the remediation is conducted when the lake is at draw down, provisions to transport the treated sediment to the barges, such as the construction of a pier, would have to be made. This consideration would be addressed during final design.

4.2.6.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness for extraction of the arsenic is similar to that presented in Alternative 3A. This alternative differs from Alternative 3A in that the extracted sediment would be transported by a barge equipped with a pneumatic pump for dry solids to those areas of Union Lake and disposed of. In the more accessible areas the treated sediments would be transported by trucks and manually deposited. Dust suppression methods would be required when transferring the sediment to the barge or truck and when discharging the sediment via pneumatic pumps to the lake. On-site workers would be properly protected with personal protective equipment. As the lake will likely be closed during the remedial action, and there is no industrial shipping on the lake, the barge traffic would not have an adverse impact. There would be no appreciable truck-related effects and the traffic associated adverse impacts on the environment would be minimal.

Potential short-term environmental impacts could occur as a result of the implementation of this alternative. Discharge of the extracted material may cause temporary resuspension of contaminated sediments. The resuspension would be localized and if deemed necessary, could be controlled through the use of silt curtains. The treated material would be discharged uniformly over the areas of remediation to prevent any mounding of the material. Fish, wildlife and biota could be impacted during the discharge, however this would be temporary.

The time required to complete this remedial action and to achieve protection is approximately three years.

- <u>Long-Term Effectiveness</u>: Alternative 3C has essentially the same long-term beneficial effectiveness as Alternative 3B; additional concerns would arise over the deposition of the treated sediments in a natural, less controlled environment than a man-made landfill. The fundamental premise that would enable implementation of this alternative to allow for lake deposition would be the determination by the USEPA's Region II Regional Administrator that the cleaned sands can be delisted based on requirements, and the determination by the NJDEP that the sediments do not exhibit the characteristics of and would not be classified as ID 27 waste. Thus long-term adverse impacts to humans and the environment from the treated materials would have been considered to be minimal prior to implementation of this alternative. Regardless of the confidence given to the treated sediments, a long-term monitoring program would be implemented to measure the effectiveness of the remediation.

  To be redeposited in the lake, the extraction process must reduce the sediment arsenic concentration to below 20 mg/kg, the more stringent action level in the lake, and the sediments must have a leachable arsenic concentration of 0.32 mg/l or less in an EP Toxicity Test extract. The actual leaching concentration when saturated with water would presumably be less than this, since an EP Toxicity Test is performed by boiling a solid in an acetic acid solution and measuring extracted concentrations. The actual leaching concentration with water is important, however, in terms of protecting the lake water quality.

  The extracted material would be discharged uniformly over areas of remediation to restore the original contours of the lake, which could result in minor impacts to the natural channel flow of the lake. The adverse environmental impacts would be minimal.

As discussed in Alternative 3A, this alternative would remove and treat sediments identified as a potential public health risk. The cancer risk associated with sediment ingestion would be reduced to 2×10^{-6} in the more accessible areas and, 1×10^{-5} in the less accessible areas. Thus this alternative would be protective of human health.

Long-term monitoring would be required to measure the effectiveness of this alternative and to monitor the redistribution patterns of the sediment. As discussed previously, the contaminated sediments remaining in the lake could potentially redistribute into areas where sediment ingestion could become a feasible exposure pathway (in water depths less than two and one half feet). Additional remedial actions would be necessary if this occurs. As contaminated sediments will remain on-site, CERCLA, as amended, would require a review of the site every five years.

- <u>Reduction of Toxicity, Mobility, and Volume</u>: Hydraulic dredging or excavation of the sediments identified as being detrimental to human health would reduce the toxicity, mobility, and volume of contaminants in Union Lake. Water extraction would desorb arsenic from sediments while chemical precipitation would remove soluble forms of arsenic from water. Discharge of treated waste water to the lake and deposition of treated sediments would account for the addition of minor amounts of mobile toxic contaminants to the ecosystem. The volume of arsenic contaminants in sensitive health risk areas would be reduced to acceptable standards. The mobility of arsenic in those areas would be reduced, as there would no longer be a source for contaminant suspension or migration once the sediments are removed.

  This alternative would essentially offer the same reduction of toxicity and volume as the other two extraction alternatives; however, the lack of a controlled landfill to monitor the mobility of contaminants would be inherent with its implementation, thus placing it at a slight disadvantage to the other two alternatives. Recognizing the fact that deposition would not be achievable without first treating the sediments to low, acceptable leaching levels meeting substantive delisting requirements, this alternative has similar advantages that landfilling might offer.

- <u>Implementability</u>

  <u>Technical Feasibility</u>: As previously discussed, the technologies to dredge or excavate, water wash, physically and chemically treat the Union Lake sediments and water are

highly feasible, available, and reliable. The availability and reliability of barges and pneumatic pumps to deposit treated sediments in the remediated areas of the lake are considered to be equally as high. Numerous licensed vendors experienced in sludge disposal can be obtained to haul, treat, and landfill concentrated treatment residues.

The sediments must be classified as non-ID 27 waste by NJDEP in order to be deposited in the lake. A substantive requirement for classification as non ID 27 waste is a reduction in the sediment arsenic concentration to 20 mg/kg, the more stringent action level in the lake. If, during final design, it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting media would be required. Treatability tests indicated that sodium citrate would reduce the sediment arsenic concentration to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediments.

The overall technical feasibility of this alternative is considered to be high. The lack of sophisticated monitoring equipment to track deposited sediment movement over the course of time places this alternative at a slight disadvantage to the alternatives with landfilling options. Considering the fact that the deposited sediments would contain arsenic concentrations within regulated leaching limits, this disadvantage becomes inconsequential. It should be noted that backfilling the dredged/excavated areas of the lake would be necessary in all of the removal and treatment alternatives considered. The only difference is that the cleaned sediments would be backfilled in this alternative rather than bringing in clean fill as would be done with Alternatives 3A and 3B.

<u>Administrative Feasibility</u>: Administrative concerns for this alternative would initially be most concentrated upon obtaining clearance for treated wastewater discharge and treated sediment deposition into Union Lake; long-term concerns would be focused upon periodic monitoring programs and five-year reviews. Additional concerns would arise from the off-site hazardous disposal of treatment sludges, which as stated in the previous extraction alternatives would be viable from an administrative viewpoint.

Since the treated sediments would be deposited on-site, a delisting petition to the NJDEP would not be necessary. Rather, according to USEPA SPGB personnel, the Regional Administrator in USEPA's Region II could authorize non-hazardous disposal provided the delisting requirements are met. Following delisting, the NJDEP would be responsible for classifying the material for ultimate disposition.

The discharge of treated wastewater would not require a permit, since it would take place on a Superfund site. As long as the discharge meets all ARARs, state and local approval should be obtainable. Other regulatory requirements would have to be met. These requirements would most likely fall under the jurisdiction of the Clean Water Act, particularly, Sections 401 and 404. Assuming these permits are obtained and all other ARARs are met, lake deposition of the treated sediments should be feasible.

As discussed previously in the other alternatives, substantial institutional effort would be required to carry out periodic site evaluations and five-year reviews. These long-term concerns would be manageable from an administrative viewpoint. Thus this alternative is considered to be administratively feasible.

- <u>Cost</u>: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at drawdown. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-6, is estimated to be $11,265,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table B-14, are approximately $1,832,000 and $13,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $14,752,000. This represents all of the activities to dredge, extract with water, and redeposit the sediments; to treat the contaminated extractant; haul and landfill the hazardous sludges; to perform all operation and maintenance functions on the treatment system components; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

  A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at its full condition were $20,064,000 and $28,351,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +36% to +92% over the estimated present worth cost of the base case. The costs are summarized in Table 4-3 and graphically presented in Figure 4-2.

  The capital cost for this alternative with the lake at drawdown, as outlined in Table C-5, is estimated to be $9,498,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table C-12, are approximately $1,808,000 and $13,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $12,942,000. This represents all of the activities to excavate, extract with water, and redeposit the sediments; to treat the contaminated extractant; haul and landfill the hazardous sludge; perform all operation and maintenance functions on the treatment system components; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at draw down condition were $16,747,000 and $22,683,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +29% to +75% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-4 and graphically presented in Figure 4-3.

If the extracted sediments fail to pass the leaching criterion to be considered delistable, this alternative may not be feasible. Regulatory approval to dispose of a listed hazardous waste in a recreational lake, despite the fact that the sediments were removed from the lake and would have been treated to meet delisting requirements, is considered unlikely. RCRA LDR consideration would apply to the sediments if they were not delistable, therefore they would have to be disposed of in a Subtitle C hazardous waste facility (assuming they met the 1 mg/l treatability variance).

o <u>Compliance with ARARs</u>: The same action-specific ARARs and key regulations that apply to hydraulic dredging or excavation, extraction and extractant and supernatant treatment and discharge activities discussed in Alternative 3A are applicable for this alternative, including the U.S. Fish and Wildlife Coordination Act, the Clean Water Act and RCRA LDRs. Deposition of the extracted sediment would comply with Sections 401 and 404 of the CWA. The extracted sediment is assumed to be delistable and thus is not subject to the RCRA LDRs. It is expected that this alternative would comply with all identified ARARs.

o <u>Overall Protection of Human Health and the Environment</u>: Alternative 3C would provide the same overall protection of human health as discussed in Alternative 3A. The beneficial impact would include reducing the sediment ingestion cancer risk level to 2×10^{-6} in the more accessible areas and 1 x 10^{-5} in the less accessible areas. If the remaining contaminated sediment redistributes to areas where sediment ingestion is a feasible pathway, additional remedial actions would be required to adequately protect human health.

The implementation of this alternative may improve the lacustrine ecosystem by reducing the potential exposure pathways of the arsenic contaminants to the fish and wildlife.

- o <u>State Acceptance</u>: No specific comments were received pertaining to the lake deposition of the treated sediments. General comments mentioned previously are applicable to this alternative.

- o <u>Community Acceptance</u>: No public comments have been received to date.

4.2.7 <u>Alternative 3D - Removal/Extraction/Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal</u>

4.2.7.1 Description

The major features of this alternative include hydraulic dredging or excavation of contaminated sediments, two-stage water extraction of the dewatered sediments, supernatant water treatment and extractant treatment with discharge to Union Lake, uniform deposition of treated sediments on the ViChem plant site, and off-site hazardous disposal of treatment sludges. This is a source control (removal and treatment) alternative and is exactly the same as Alternative 3A, 3B and 3C except that the treated sediments would deposited on the ViChem plant site.

- o <u>Plant Site Deposition</u>

The treated lake sediments would be transported by trucks to the ViChem plant site and deposited in the undeveloped areas of the site (approximately 25 acres). Approximately 117,000 cubic yards of treated sediment would be deposited on the site. Bulldozers, compactors and graders would work conjunctively to cut and fill the deposition areas to establish new topography. This topography would be designed to maintain the present runoff on and off the site. Temporary construction controls such as silt fences, haybails, and runoff diversion ditches would be established to protect the site and adjacent properties. When deposition is complete, clean fill and/or seeded topsoil would be used to protectively cover the areas from natural eroding forces.

The major construction components and facilities for this alternative are outlined in Table A-7 of Appendix A.

4.2.7.2 Assessment

- <u>Short Term Effectiveness</u>: The short-term effectiveness of Alternative 3D is very similar to that already presented for Alternative 3B. Alternative 3D differs in that the treated sediments would be deposited directly on the plant site, instead of a landfill. Short-term concerns over dust generation, protection of workers and the public, and the increased traffic would be handled accordingly, as described in Alternative 3B. Additional measures such as fencing and security would be taken to minimize access to the plant site during the implementation of the alternative. Depositing the material on the plant site would have no different short-term effectiveness than depositing the material in an on-site nonhazardous landfill. The time to complete the remediation would be approximately three years.

- <u>Long-Term Effectiveness</u>: Alternative 3D has essentially the same long-term effectiveness as Alternative 3B and 3C. As discussed in Alternative 3C, concerns would arise over the deposition of the treated sediments in a natural, less controlled environment than a manmade landfill. This alternative could only be implemented if the treated sediments were delisted by the USEPA Region II Regional Administrator and classified by the NJDEP as non-ID 27 waste. In order to be delisted, the treated sediments must have a leachable arsenic concentration of 0.32 mg/l or less in an EP Toxicity Test extract as established by the VHS model. Classification as non-ID 27 waste would require a reduction in the sediment arsenic concentration to below 20 mg/kg the more stringent action level. Thus the long-term impacts to human health and the environment would be considered prior to implementation of this alternative.

  The remaining long-term concerns associated with this alternative would be identical to those presented in Alternative 3B. This action would reduce cancer risk levels to 2×10^{-6} in the more accessible areas of the lake and 1×10^{-5} in the less accessible areas. Recreational use of the lake could be instituted following completion of remediation. Secondary waste management issues would be negligible since the hazardous treatment sludges would be handled at a licensed off-site facility.

  A long-term monitoring program would be implemented to monitor sediment distribution patterns in the lake and to measure the effectiveness of the remediation, with particular attention given to evaluating groundwater for the appearance of leachate from the treated sediments.

- **Reduction of Toxicity, Mobility or Volume**: This alternative would greatly reduce the toxicity, mobility and volume of arsenic-contaminated sediments in the lake to the extent that acceptable risks to human health would be achieved in the accessible areas of the lake. The toxicity and volume of arsenic would be reduced by extracting the arsenic from the sediments, altering its form through oxidation, consolidating it into a sludge, and disposing of it to a vendor equipped with technologies to safely manage it. The mobility of arsenic in the environment would decrease, although not to the extent that could be achieved if placed in a properly lined and capped landfill. The control of leaching of contaminants into groundwater would be more attainable with a lined landfill, a cap and a leachate collection system.

- **Implementability**:

  Technical Feasibility: The technical feasibility of the dredging, excavation, extraction, wastewater treatment, and sludge disposal operations are identical to those presented in Alternatives 3A and 3B. All are considered to be highly available, reliable and implementable. Plant site deposition of the treated sediments with associated compacting and grading activities is considered to be technically achievable since it would involve standard construction practices.

  The sediments must be classified as non-ID 27 waste by NJDEP in order to be deposited on the plant site. A substantive requirement for classification as non-ID 27 waste is a reduction in the sediment arsenic concentration to 20 mg/kg, the plant site action level for soils and the more stringent action level in the lake. If, during final design it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting medium would be required. The treatability studies indicated that extraction utilizing sodium citrate would reduce the sediment arsenic concentra- tion to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediment.

  Plant site deposition of the treated lake sediments would require standard earthwork equipment and construction practices to develop the on-site topography without hindering off-site flow. These are standard construction practices and as such are considered easily implementable. A greater land area would be available for on-site deposition than for an on-site nonhazardous landfill, since there are certain restrictions in locating a landfill in close proximity to property boundaries. Since there is more land area, the material could be spread more thinly creating less of a mound. Additionally, site deposition does not require the inclusion of the clay liners and leachate collection systems associated with a landfill. Also, a four foot bottom and top layer would not be required, meaning the deposited areas would not be as high as a landfill (4 ft. vs 20 ft.).

Administrative Feasibility: Deposition of treated sediments would require a considerable administrative effort to reach fruition. Prior to remediation of the lake, a number of decisions regarding the fate of the treated sediments would have to be made. First, if deposition at the plant site is classified as "on-site", delisting, which has been shown as feasible, would be implemented by USEPA Region II. Otherwise, the NJDEP would have to be petitioned for a delisting classification for the treated sediments. Since the plant site would be considered "on-site," a lengthy petitioning process would be avoided.

Following delisting, the NJDEP would be responsible for classifying the material for ultimate disposition. According to New Jersey Solid/Hazardous Waste Rules (refer to NJAC 7:25-1.6), solid waste are generally regarded as materials that either no longer serve a beneficial use or are being disposed of such that their constituents can be released to the environment. Following treatment, the sediments would contain leachable arsenic below the regulatory disposal levels. Therefore, deposition of the treated sediments would pose minimal threat to human health and the environment.

The discharge of treated water from the extraction process would not require a permit; however, a statement that all ARARs would be obtained would have to be provided. As discussed in the other alternatives, substantial institutional effort would be required to carry out periodic site evaluations and five-year reviews. These long-term concerns could be manageable from an administrative viewpoint. Thus this alternative is considered to be administratively feasible.

- Cost: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at drawdown. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-7, is estimated to be $14,746,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table B-15, are approximately $1,832,000 and $13,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is

$18,233,000. This represents all of the activities to dredge, extract with water, and redeposit the sediments; to treat the contaminated extractant; haul and landfill the hazardous sludges; to perform all operation and maintenance functions on the treatment system components; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at its full condition were $25,330,000 and $36,400,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +39% to +100 % over the estimated present worth cost of the base case. The costs are summarized in Table 4-3 and graphically presented in Figure 4-2.

The capital cost for this alternative with the lake at drawdown, as outlined in Table C-6, is estimated to be $12,978,000. Short-term and long-term operation and maintenance costs for this alternative, outlined in Table C-13, are approximately $1,808,000 and $13,000, respectively. The present worth cost, calculated at a discount rate of 5% after inflation, is $16,422,000. This represents all of the activities to excavate, extract with water, and redeposit the sediments; treat the contaminated extractant; haul and landfill the hazardous sludge; perform all operation and maintenance functions on the treatment system components; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the volume of contaminated sediment to be removed. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at draw down condition were $22,012,000 and $30,732,000 for the five-foot water depth and ten-foot water depth, respectively. These costs represent a difference of +34% to +87% over the estimated present worth costs of the alternative. The costs are summarized in Table 4-4 and graphically presented in Figure 4-3.

If the extracted sediments fail to pass the leachin criterion to be considered delistable, this alternative ma not be feasible. Regulatory approval to dispose of listed hazardous waste in a recreational lake, despite th

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fact that the sediments were removed from the lake and would have been treated to meet delisting requirements, is considered unlikely. RCRA LDR consideration would apply to the sediments if they were not delistable, therefore they would have to be disposed of in a Subtitle C hazardous waste facility (assuming they met the 1 mg/l treatability variance).

- Compliance with ARARs: The same action-specific ARARs and key regulations that apply to hydraulic dredging, two-stage extraction and supernatant treatment and discharge activities discussed in Alternative 3A are applicable for this alternative, including the U.S. Fish and Wildlife Coordination Act, the Clean Water Act and RCRA LDRs. The extracted sediment is assumed to meet delisting requirements and thus is not subject to the RCRA LDRs. It is expected that this alternative would comply with all identified ARARs.

- Overall Protection of Human Health and the Environment: Alternative 3D would provide the same overall protection of human health as discussed in Alternative 3A. The beneficial impact would include reducing the sediment cancer risk to levels protective of human health. If the remaining contaminated sediment redistributes to areas where sediment exposure is a feasible pathway, additional remedial actions would be required to adequately protect human health.

  The implementation of this alternative may improve the riverine ecosystem by reducing the potential exposure pathways of the arsenic contaminants to the fish and wildlife.

- State Acceptance: In addition to the comments mentioned previously, this alternative addresses a major state comment, namely that alternatives be considered that did not require either on-site or off-site landfill disposal.

- Community Acceptance: No public comments have been received to date.

4.2.8 Alternative 5 - In Situ Sand Covering

4.2.8.1 Description

The major feature of this alternative involves placing clean coarse sand atop contaminated sediments that exceed the remediation criteria discussed in Section 2.0. The coarse sand would be distributed to those contaminated areas via a barge equipped with pneumatic pumps for dry materials handling or diffuser discharge heads for the deeper portions of this area, or would be spread by trucks or front-end loaders and graded. Approximately 131,000 cubic yards of sand would be required for the covering.

Long-term monitoring of the lake would be required to evaluate the performance of this alternative. The monitoring would consist of an annual inspection of the site, as well as environmental sampling and chemical analysis of the samples for arsenic. If it is determined that the coarse sand cover has been significantly disrupted or does not meet the intended use, additional clean coarse sand may be required for application and regrading. Because this alternative would result in contaminated sediment remaining on-site, CERCLA as amended would require that the site must be reviewed every five years.

The major work items associated with this alternative include:

- Mobilization/demobilization of equipment and operations;
- Delivery of clean coarse sand (incremental applications);
- Application and grading (where necessary) of coarse sand cover in those areas identified;
- Annual inspections of the site to determine if conditions have changed dramatically, or if the cover has been significantly disrupted;
- Annual sampling of the lake sediment and lake water and analysis of arsenic to monitor contaminant concentrations and any associated migration;
- Assessment of whether the sand cover meets the remedial objectives for this alternative, and identification of the need for any additional clean sand covering and regrading operation; and
- Performance of site reviews every five years.

4.2.8.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness concerns associated with this alternative include public health threats and adverse impacts on the environment.

  The covering of the contaminated sediments may have significant impacts on the lake ecosystem if the remediation is conducted when the lake is at its full condition. The application of the one-foot coarse sand cover and any grading activities may result in temporary sediment and sand particulate suspension. However, as the areas of remediation are relatively shallow, particulates would settle within a short period of time. Regardless if the lake is full or at the drawdown condition at the initiation of the remedial action, the shoreline would essentially be regraded. Pooled areas of quiescent water, which serve as hatching and/or feeding areas, may be eliminated. As a result, direct adverse impacts may occur to the habitats of biota, fish and wildlife.

It is estimated that during the implementation of this alternative, approximately 10,100 truckloads of clean coarse sand (13 cubic yards per load) would be required to provide enough cover material. As a result of the increased traffic conditions, temporary increases in noise and air pollution levels and the occurrences of vehicular accidents may be associated with the construction activities. In addition, transferring the clean sands to barges or dumping sands for grading may result in fugitive dust emissions. However, the impact of each of these temporary conditions can be minimized through the implementation of appropriate construction control plans, traffic control plans, and dust control measures (e.g., water spray).

Construction workers would not come into direct contact with the contaminated sediments, as no excavation or handling of sediments would be involved. Coarse sand application would be accomplished through the use of barges equipped with pneumatic pumps or diffuser discharge heads. In areas where the sediment is submerged the sand would be discharged from the pump hose below the water surface in order to minimize any disturbance. In areas of shallow water depth near the lake shore and areas along the lake shore, sand would be applied by truck or front end loader, and then regraded. As previously mentioned, fugitive dust may be emitted during the transfer of clean sands by the appropriate application equipment. Since this is clean sand, appropriate dust control measures could be employed to minimize worker and public exposure.

- <u>Long-Term Effectiveness</u>: The coarse sand cover would reduce the potential of ingestion of those sediments identified in the risk assessment as a public health risk. Therefore the cancer risk in the areas of remediation would be reduced. However, only approximately five percent of the arsenic contaminated sediments contained in the lake would be covered. Several instances could arise whereby arsenic contamination could be redistributed. Incoming water to the lake from the river could carry additional arsenic contamination, which could subsequently adsorb onto the sediments. Natural water dynamics, human disturbance of the sediments or cover during swimming or jogging, children digging in the sand cover, or the growth of vegetation are examples of mechanisms that may redistribute contaminated sediments. Any of these occurrences may result in previously clean sediment areas exceeding the action level, or may result in previously contaminated areas becoming clean. Therefore, annual monitoring would be required to measure the effectiveness of this alternative and monitor the redistribution pattern of the lake sediment.

Because this alternative would result in the contaminated sediments remaining on-site, CERCLA as amended would also require that the site be reviewed every five years to determine the effectiveness of the alternative or if new technologies could be applied to the problems at this particular site.

Based upon the review of the annual monitoring program findings, an assessment would be made to determine if the objectives set for this alternative are met. The level of certainty for this alternative in meeting the objectives is low due to untreated residual contamination remaining in the lake. Additional clean coarse sand may be required in new or already covered areas, or regrading may be performed. If chemical data reveal significant levels of arsenic, additional steps for remediation may be implemented.

- <u>Reduction of Toxicity, Mobility, or Volume</u>: As a result of the implementation of this alternative, there would be no reduction in the toxicity or volume of contaminated sediments in the lake. The sand cover would act as a temporary measure to reduce the potential for ingestion of the contaminated sediments located in the shallow waters of the lake. This cover would significantly reduce the physical mobility of arsenic from the underlying sediments, but would not eliminate potential exposure to the underlying sediments, as the cover may easily be disrupted or scoured. In addition, the potential for the leaching of arsenic from the contaminated sediments into the lake water or adsorbing to the clean sand or other sediments still exists due to the high permeability of the cover material.

- <u>Implementability</u>

  <u>Technical Feasibility</u>: The application of the coarse sand cover is a relatively simple and conventional technique that may be accomplished through the use of pneumatic pumping and barges, or dumping via trucks and/or front-end loaders with subsequent grading. Coarse sand is a common construction material that is locally available. Associated difficulties with this particular application when the lake is at its full condition involve the potential for sediment disturbance and resuspension by the barge at shallow water depths (i.e., 2.5 feet), and by the physical application of

the cover sand. As there are contaminated sediments above the action level that are located immediately outside the remediation areas, there is a potential that a high degree of turbulence would resuspend or disperse the exposed contaminated sediments. These sediments could then settle atop the clean sand cover. Considerations must be given when selecting the barge type to the minimum clearance required by the barge with a full load and location of the barge's propeller to minimize this potential disturbance.

Application techniques may also be selected in order to minimize the potential for contaminated sediment disturbance. Point dumping from the truck or from a front-end loader would tend to resuspend the sediment and result in high turbidity in the vicinity of the operations. Pumpdown methods, as with barges and pneumatic pumps, could be used to reduce the amount of sediment disturbance, resuspension, and turbidity increase in the surrounding water by discharging the cover material close to the surface of the sediments. However, the typical method of operation may require modification in order to work in the shallow waters for Union Lake. Upon application of these techniques, it may be difficult to ensure that the one-foot of sand cover extends over the submerged contaminated sediments. In the more shallow areas of the lake sediments which require covering, it would be easier through the use of grading equipment to establish the one-foot sand cover. Another technique, a submerged diffuser system, could be used to reduce the turbidity resulting from the cover application, decrease scouring of the area, and also provide a more accurate system by which the one-foot cover could be applied. The diffuser head could cause radial divergence of the flow of the cover material, thereby reducing the discharge velocity of the applied cover material to acceptable levels. By varying the height of the discharge above the contaminated sediment as well as the discharge velocity, impact of the velocity and the thickness of the cover can be controlled. Additional consideration would be required to address any areas of limited access encountered during the remedial action.

Application of the sand cover when the lake is drawn down presents several advantages over the application when the lake is at its full condition, as some of the contaminated sediments scheduled to be covered would be exposed with the lake at the drawdown condition facilitating some use of trucks, front-end loaders and graders. Utilization of this type of equipment allows much greater control ensuring that the sand cover extends over the contaminated sediment at a depth of one foot. Additionally, it is expected that most of the remediation areas would be accessible when the lake is at drawdown.

Should the annual monitoring program reveal that significant levels of arsenic are present, or that the sand cover is not providing the level of protection intended by its use, then additional measures would be required. These measures may include the additional application of more clean sand cover, regrading existing cover areas, or, if conditions warrant, excavating and/or treating the contaminated matrix (e.g., sediment or water). The present alternative actions would generally not interfere with any of these additional measures. However, in order to excavate or treat those sediments that have already been covered, additional material handling, and an increased volume for treatment, would be required.

The major limitation associated with this alternative is that the feasibility and effectiveness of the method employed has not been fully demonstrated for the containment of hazardous waste contaminated sediments. Covering methods have been utilized at several sites recently, but the long-term reliability and effectiveness of this alternative is not yet known.

Administrative Feasibility: The implementation of this alternative would result in the modification of a water body. As such, coordination with the U.S. Fish and Wildlife Services must be performed prior to the implementation of the alternative. If the remediation is conducted when the lake is full, access to certain areas of the lake sediments requiring sand covering may be difficult from public property. Coordination with private homeowners may be required to obtain access. As required by CERCLA, as amended, the site must be reviewed every five years to determine the effectiveness of the alternative or if new technologies could be applied to the problems at this particulate site. As no treatment or disposal is anticipated, no additional permits are required and RCRA LDR considerations are not applicable to this alternative.

The trucks delivering the estimated 131,000 cubic yards of clean coarse sand would be scheduled based upon assumed application rates. While limited storage would be available at the public beach, the area is not of sufficient size to accommodate the entire load required for alternative implementation. Administrative effort would be required to schedule the delivery of the sand so as not to delay the project.

- Cost: The costs for this alternative have been estimated considering the lake at its full condition and considering the lake at drawdown. The capital cost for this alternative with the lake at its full condition, as outlined in Table B-8, is estimated to be $3,145,000. No short-term operation

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and maintenance costs are associated with this alternative. Long-term operation and maintenance costs for this alternative, outlined in Table B-16, are approximately $13,000 (per year for 30 years). The present worth cost, calculated at a discount rate of 5% after inflation, is $3,369,000. This represents all of the activities to place a one-foot layer of sand over the 131,000 square feet of contaminated sediment; perform all operation and maintenance functions on the sand cover; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the areal extent of the sand cover. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at its full condition were $5,454,000 and $8,706,000 for the five-foot water depth and 10-foot water depth, respectively. These costs represent a difference of +62% to +158% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-3. A graphical representation is depicted in Figure 4-2.

The capital cost for this alternative with the lake at drawdown, as outlined in Table C-7, is estimated to be $2,176,000. No short-term operation and maintenance costs are associated with this alternative. Long-term operation and maintenance costs for this alternative, outlined in Table C-14, are approximately $13,000. The present worth cost, valued at $2,400,000, represents all of the activities to place a one-foot layer of sand over the 131,000 square feet of contaminated sediment; perform all operation and maintenance functions on the sand cover; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

A cost sensitivity analysis was performed for this alternative by varying the water depth to which remediation would be conducted, thus varying the areal extent of the sand cover. Sensitivity to water depth was analyzed at a five-foot water depth and a ten-foot water depth. Present worth costs considering the lake at draw down condition were $3,759,000 and $5,877,000 for the five-foot water depth and 10-foot water depth, respectively. These costs represent a range of +57% to +145% over the estimated present worth cost of the alternative. The costs are summarized in Table 4-4 and are graphically presented in Figure 4-3.

o <u>Compliance With ARARs</u>: The U.S. Fish and Wildlife Coordination Act requires that any appropriate agency exercising jurisdiction over a wildlife resource, and the U.S. Fish and Wildlife Service, be consulted before undertaking any action that modifies a water body. Special attention must be given to the impact on wetlands and flood-plains (lake shores) in accordance with Executive Orders 11990 and 11888. Placement of a one-foot sand layer over portions of the 870 acre lake would constitute modification of a water body. Therefore, coordination with the proper agency and the U.S. Fish and Wildlife Service would be conducted to ensure that this alternative would comply with this ARAR. In addition, the National Endangered Species Act requires that special attention be given to the impact on areas where endangered species reside.

The placement of the sand layer when the lake is at its full condition would constitute a discharge according to the CWA. Section 401 and Section 404 specify that the existing contaminant levels not be violated and that no remedial alternative affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. Prior to placement of the sand cover, the sand would be sampled to ensure that it is not contaminated. As the sand would be from a clean source, the chemical, physical and biological integrity of the lake would not be violated. However, temporary and localized physical impacts to the wetland including resuspension and/or relocation of contaminated sediments would result from the implementation of this alternative when the lake is full. Additionally, installation of access roads to some areas may be required. These access roads would be demolished after the completion of the remediation and the wetland would be restored to its original condition with minimal impact. Based on the above discussion, excavation, of the contaminated sediments when the lake is drawn down is favored over dredging relative to the CWA.

Activities during this remediation would be subject to OSHA industry standards and regulations.

At the start of the remedial design, a Stage IA Survey consisting of a comprehensive literature search, would be conducted according to the National Historic Preservation Act.

Because this alternative does not involve any removal, treatment or placement of wastes, RCRA LDRs are not applicable.

o <u>Overall Protection of Human Health and the Environment</u>: This alternative would not involve any removal or treatment of the contaminated sediments identified as a public health risk. It would provide a type of containment of the sediment by placing a one-foot sand layer atop those sediments. This cover would reduce the potential for sediment ingestion, thus reducing the cancer risk level to

2×10^{-6} in the more accessible areas and 1×10^{-5} in the less accessible areas. Natural sediment redistribution patterns, human disturbance and vegetative growth may cause sediments with concentrations greater than the action level to be redistributed in areas where sediment ingestion is feasible. If this occurs additional remedial actions would be required to meet the target cancer risk level.

- <u>State Acceptance</u>: No state comments were received regarding this specific alternative. The general comments previously discussed are applicable to this alternative.

- <u>Community Acceptance</u>: No public comments have been received to date.

4.3 COMPARISON AMONG ALTERNATIVES

A comparative analysis will be conducted in this section to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another.

The following lists the alternatives to be compared in this section:

Alternative 1:	No Action
Alternative 2A:	Removal/Fixation/Off-Site Nonhazardous Landfill
Alternative 2B:	Removal/Fixation/On-Site Nonhazardous Landfill
Alternative 3A:	Removal/Extraction/Sediments to Off-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal
Alternative 3B:	Removal/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
Alternative 3C:	Removal/Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal
Alternative 3D:	Removal/Extraction/Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal
Alternative 5:	In Situ Sand Cover

4.3.1 Short-Term Effectiveness

The implementation of Alternative 1 would result in minimal short-term effects to the local community. However, it would possibly restrict the use of the lake. There would be no construction involved at the site, no threat to neighboring communities, and no significant impacts on the public health and environment during the remedial action. Education programs and public meetings would be presented to the neighboring communities during the remedial action.

The implementation of Alternatives 2A, 2B, 3A, 3B, 3C and 3D would pose potential public health threats to the neighboring communities via direct contact with spilled wastes and the inhalation of fugitive dust. While the chemicals involved in Alternatives 2A and 2B would be stored in closed silos equipped with dust emission control devices, there would be a potential for limited dust emissions. In Alternatives 3A, 3B, 3C and 3D the chemicals utilized are either liquid or granular in nature as opposed to a fine dust. The implementation of Alternatives 2A, 2B, 3A, 3B, 3C or 3D would present minor threats to public health. Alternative 5 would present minimal threats to the community as no sediment would be removed. Potential impacts include fugitive dust emissions during placement of the sand cover. Standard construction dust-suppression techniques would minimize this threat.

During the implementation of all alternatives, on-site workers would be provided with personnel protective equipment to minimize exposures from direct contact with wastes, chemicals and the inhalation of fugitive dust.

There would be no significant adverse impacts on the environment during the implementation of Alternative 1. Alternatives 2A, 2B, 3A, 3B, 3C, 3D and 5 pose some environmental impacts, which include an increase in traffic from construction activities, the transportation of sediments, and the transportation of sand for the cover. The increased truck traffic might result in an increase in traffic accidents. The construction activity and increased truck traffic pose a potential increase in air pollution, noise pollution and increased exposure to spilled wastes. Proper traffic control and dust suppression measures would be required to minimize these short-term adverse environmental impacts.

If the remediation is conducted when the lake is at its full condition, hydraulic dredging would be utilized to remove the contaminated sediment. Hydraulic dredging activities which would be conducted in Alternatives 2A, 2B, 3A, 3B, 3C and 3D mav pose potential adverse environmental impacts. These impacts m include localized sediment resuspension and could temporari affect biota. Since the dredging would be limited to loc shallow water areas, suspensions would settle in a short period of time. Additionally, silt curtains would be used to prevent migration of any resuspended sediment. The dredging activities could disturb wetland areas therefore measures may have to be taken to restore the wetland areas.

Excavation of the sediments would be performed in Alternatives 2A, 2B, 3A, 3B, 3C and 3D if the remediation is conducted when the lake is at drawdown. Fewer potential adverse environmental impacts are associated with dry excavation; the sediments would be exposed allowing greater control in the removal of contaminated sediments. Dust suppression techniques would be utilized to prevent the release of fugitive dust. If any wetland areas are disturbed during the excavation, measures would be taken to restore the areas.

Implementation of Alternative 3C and Alternative 5 (if remediation is conducted when the lake is at its full condition) may result in temporary and localized short-term impacts to the lake. Redeposition of the extracted sediments and the dispersion of sand from the covering in Alternative 5 may result in resuspension of contaminated sediments. The potential for resuspension could be minimized through the use of diffuser-type equipment. If resuspension does occur, migration of the particulate matter could be minimized through the utilization of silt curtains. Dispersion of both the treated sediments and sand would be conducted to avoid piling of the material, which could impact boating activities.

If remediation is conducted when the lake is at drawdown, Alternative 5 could be implemented utilizing dry application equipment such as trucks, front-end loaders and graders. Barges would be utilized to transport the sand to the remediation areas. This method of application would not only have substantially fewer environmental impacts but would also allow greater control over the areal extent of the sand cover and the depth of the cover.

The time required to achieve protection for Alternative 1 would be approximately three to four weeks. This would include monitoring the lake and posting warning signs. The time required to complete Alternatives 2A and 2B, 3A, 3B, 3C and 3D is estimated to be three years. One year is required for Alternative 5. The estimated time periods run from the start of construction to the completion of treatment and disposal activities.

4.3.2 Long-Term Effectiveness

The implementation of Alternative 1 would result in a large residual risk remaining on-site, as the arsenic-contaminated sediment would not be removed from the lake or treated in place. It would require some years for natural attenuation and transport mechanisms in the lake to significantly reduce the volume of arsenic in the sediment. This alternative would prevent the ingestion of contaminated sediments by restricting access to the lake. The long-term effectiveness of the alternative in minimizing human health risks would depend on its success in preventing access to the site.

After implementation of either Alternatives 2A, 2B, 3A, 3B, 3C, 3D, or 5, the sediment ingestion risk would be reduced to below the target level of $2x10^{-6}$ in the more accessible areas of the lake and $1x10^{-5}$ in the less accessible areas. These alternatives would remove and treat those sediments identified as a public health risk, except for Alternative 5 which would contain the contaminated sediments, thus reducing the exposure risks. However, contaminated sediments with concentrations above the target level would remain in the lake, although in areas not deemed a public health risk. If significant redistribution of the sediments occurs via natural lake dynamics, human disturbance or the growth of vegetation, resulting in accessible areas containing these sediments, the public health risk would be greater than the target. Thus additional remedial actions may be required.

The treated sediments from either extraction or fixation are expected to be delistable and thus could be disposed of as nonhazardous material either in an off-site nonhazardous landfill, an on-site nonhazardous landfill or deposited in the remediation areas or on the plant site. The supernatant water from the dredging activities, which would be performed if the remediation is conducted with the lake at its full condition, and the extractant water from the extraction of the contaminated sediments, would be treated by standard physical-chemical wastewater treatment processes to remove arsenic to levels below 0.05 mg/l, which meets the NJPDES requirements and New Jersey Surface Water Quality Standards, before the water is discharged to the lake. The arsenic contaminated sludge generated from the extraction process would be transported to an off-site RCRA treatment and disposal facility. The sludge would ultimately be disposed of in RCRA Subtitle C landfill.

Alternatives 2A, 2B, 3A, 3B, 3C, and 3D employ treatment technologies that solidify or extract arsenic in the sediments. Both technologies have been tested and are proven. All equipment necessary for implementing these alternatives is available from several vendors. The chemicals employed in the fixation and extraction processes are all readily available. Pilot-scale studies would be performed to optimize the treatment processes. After the implementation of Alternatives 2A or 3A the off-site landfill would not require a long-term management program as part of the site remedy. Alternatives 2B and 3B include disposal of treated sediments in an on-site landfill. long-term management and maintenance program would be requir for the on-site landfill facility, however, implementation this program does not pose any problems. Alternative 3C and 3D involve lake deposition and plant site deposition, respectively. As this deposition is not in a controlled environment long-term monitoring would be required to measure the effectiveness of the alternative. Long-term monitoring of sediments remaining on-site with an arsenic concentration greater than 20 mg/kg would be required for all the alternatives to monitor for any redistribution. If these sediments collect in areas identified as posing a potential public health risk, additional actions may be required.

The reliability of control in Alternative 1 is low because the long-term effectiveness of this alternative is dependent upon restriction of site access. Alternatives 2A, 2B, 3A, 3B, 3C, and 3D are not likely to fail because the arsenic is fixed in the sediments or extracted. Any remaining arsenic is assessed to be safe from a public health standpoint. The reliability of Alternative 5 is uncertain as the sediment transport mechanisms have not been identified in the lake.

Alternative 1 would not reduce human health risks in Union Lake. Alternatives 2A, 2B, 3A, 3B, 3C, 3D and 5 would all reduce human health risks via the sediment ingestion pathway. As discussed previously, the source of arsenic into the lake water from the ViChem plant site must be eliminated to reduce the overall human health risks in the lake areas. This remedial action to manage migration should be taken before any remedial action is taken on the lake sediments.

4.3.3 Reduction of Toxicity, Mobility or Volume

Alternative 1 does not reduce the toxicity or volume of the contaminants because no arsenic is removed from Union Lake. Alternatives 2A, 2B, 3A, 3B, 3C, and 3D permanently reduce the mobility and the volume of contaminants in the lake. Alternatives 2A and 2B reduce the toxicity of the sediments in the lake, but not overall. Fixation does not change the toxicity of the arsenic; the contaminant becomes immobilized within a tightly bound matrix. Alternatives 3A, 3B, 3C, and 3D reduce the toxicity of the sediments in the lake. The form of arsenic is changed via the extractant treatment process and consolidated into a sludge for off-site hazardous waste disposal. Alternatives 2A and 2B produce a larger volume of treated sediment to be disposed of than Alternatives 3A, 3B, 3C and 3D, because the fixation process requires large volumes of additives. Alternative 5 does not reduce the toxicity or volume of contaminated sediment, however the sand covering would be expected to reduce the mobility.

Both on-site and off-site nonhazardous landfilling options offer similar reduction of mobility from treated sediments. Alternative 3C and 3D dispose of the sediments in an uncontrolled environment. As the sediments would be delisted and classified as non-ID 27 waste prior to implementation of the alternative, the inherent mobility of the contaminants would be very low. Overall, Alternatives 2A, 2B, 3A, 3B, 3C, and 3D provide permanent and essentially irreversible remedies for treatment of the contaminated sediments.

4.3.4 Implementability

The implementation of Alternative 1 consists of simple tasks, such as monitoring, inspection of the lake and posting warning signs. These tasks present no implementation difficulties. The implementation of either Alternative 2A, 2B, 3A, 3B, 3C, or 3D involves the use of standard equipment that is commercially available. There is no technology involved in Alternative 1, whereas in Alternatives 2A, 2B, 3A, 3B, 3C, and 3D the technologies are well developed and proven.

If the remediation is conducted when the lake is at its full condition, hydraulic dredging would be utilized to remove the contaminated sediment. Dredging of sediments in shallow waters is a proven technology. On-site sediment and water testing would be required to monitor the Mud Cat's effectiveness.

If the remediation is conducted when the lake is at drawdown dry excavation techniques would be utilized. Excavation is a well developed and proven means of removal. Excavation would provide a greater means of control to ensure that all contaminated sediments identified as a potential public health risk would be removed. All of the areas of remediation would be accessible through public property.

The implementation of Alternative 5 requires standard construction equipment and fill material. Technology considerations for placing a layer of sand over contaminated sediment in shallow water are minimal.

After the implementation of Alternatives 1 and 5, if additional remedial action is necessary it can be implemented with no anticipated problem. In Alternatives 2A, 2B, 3A, and 3B it is not anticipated that there would be a need for future or additional remedial actions. In the event that additional action is required, there would be no technical difficulties to overcome when implementing the task. However, a good deal of remediation would have to be done if Alternative 3C failed, since the sediment would have to be recovered from the remediation areas of Union Lake. It would be very difficult to monitor the effectiveness and recover the sediments if failure were detected. If Alternative 3D failed, the sediment could be recovered without great difficulty. Landfill failure is not expected, but is more controllable than lake deposition.

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With the application of Alternative 1, there is a need for surveillance in order to attain effective access restriction. Regular public awareness meetings would be required to increase the effectiveness of this alternative. With the application of either Alternatives 2A, 2B, 3A, 3B, 3C, 3D or 5, long-term operation and maintenance activities would include periodic site sampling, performing five-year reviews, and monitoring on-site landfills (Alternatives 2B and 3B) or deposition areas (Alternative 3C and 3D). The processes are reliable and would meet the designated efficiencies and performance goals.

No permits are required for the implementation of Alternative 1. Alternatives 2A, 2B, 3A, 3B, 3C, 3D, and 5 may require some permits. In carrying through all the alternatives, coordination would be required with other agencies to obtain all necessary agreements, particularly for Alternatives 2B, 3B, 3C, and 3D which involve constructing an on-site nonhazardous landfill facility, or the lake deposition or plant site deposition of treated materials.

Treatment capacity and disposal service requirements are not required in Alternatives 1 and 5. Treatment capacity, storage capacity and disposal services are all adequately available for Alternatives 2A, 2B, 3A, 3B, 3C, and 3D. The nonhazardous off-site landfills have the capacity to handle the treated sediments. The nonhazardous on-site landfill would be designed to contain the total amount of the treated sediments. The relocation of sediment involved in Alternative 3C should not place any burden or drastically disrupt the ecosystem of Union Lake. Plant site deposition would not adversely impact the environment.

The availability of necessary special equipment and personnel are not required for Alternatives 1 and 5. Standard equipment and operations utilized in Alternatives 2A, 2B, 3A, 3B, 3C, and 3D are commercially available.

Bench-scale tests have proven that fixation (Alternatives 2A and 2B) and two-stage extraction (Alternatives 3A, 3B, and 3C) are feasible for treating the arsenic-contaminated sediments. However, pilot-scale tests are required to provide relevant design criteria for the remedial design. Pilot-scale tests will be performed if these alternatives are selected. Since further testing is required, general comparisons between fixation and extraction treatment processes cannot be made on implementability criteria. The off-site landfill disposal would be preferred over the on-site landfill disposal. Lake deposition and plant site deposition may be preferred administratively to landfilling for its technical ease. Lake deposition of the treated sediments would eliminate the need for clean fill in the dredged/excavated areas.

4.3.5 Cost

Tables 4-5 and 4-6 present a summary of costs developed for each of the alternatives considering the lake to be at its full condition for the remediation and the lake to be at draw down for the remediation, respectively. Figure 4-7 presents a graphical comparison of the costs. The total present worth cost for Alternative 1 is estimated at $874,000 based on a 30-year period and a 5% discount rate after inflation. This includes capital costs, annual operation and maintenance costs and six five-year reviews.

The total present worth costs for Alternatives 2A, 2B, 3A, 3B, 3C, 3D, and 5, considering remediation to be conducted with the lake at its full condition ranged from a low of $3,369,000 for Alternative 5 to a high of $71,247,000 for Alternative 2A.

The total present worth costs for Alternatives 2A, 2B, 3A, 3B, 3C, 3D, and 5, considering remediation to be conducted with the lake at draw down ranged from a low of $2,400,000 for Alternative 5 to a high of $68,840,000 for Alternative 2A.

Based on the present worth analysis, there are slight differences among Alternatives 2A, 2B, 3A, 3B, 3C, and 3D. The differences are most heavily dependent upon chemical costs, in which fixation outweighs extraction, and landfilling location options, which indicate that on-site is preferable to off-site. Lake deposition and plant site deposition, the disposal options for Alternative 3C and 3D, respectively, are less costly than both landfilling options. Alternative 5, In Situ Sand Covering, does not include any chemical, disposal, or treatment costs, and is thus the least costly of all the remedial action alternatives. Without considering implementability and other factors other than cost, Alternative 3C, extraction with lake deposition, would appear to be the most economical alternative.

The sensitivity analyses performed for all of the alternatives evaluated the effect of conducting the remediation under different depths of water, effectively varying the volume of contaminated sediment to be remediated. Remediating sediments under a water depth of 5 feet and 10 feet was evaluated. All of the costs for remediation demonstrated variations within a range of +29% to +178% for the varying water depths.

4.3.6 Compliance with ARARs

Action-specific ARARs for Alternative 1 apply to the posting of warning signs and the site-monitoring activities. Requirements for these activities include OSHA Health and Safety Standards, which Alternative 1 would meet.

TABLE 4-5

SUMMARY OF COST ANALYSIS (1989 DOLLARS)
(DREDGING CASE)

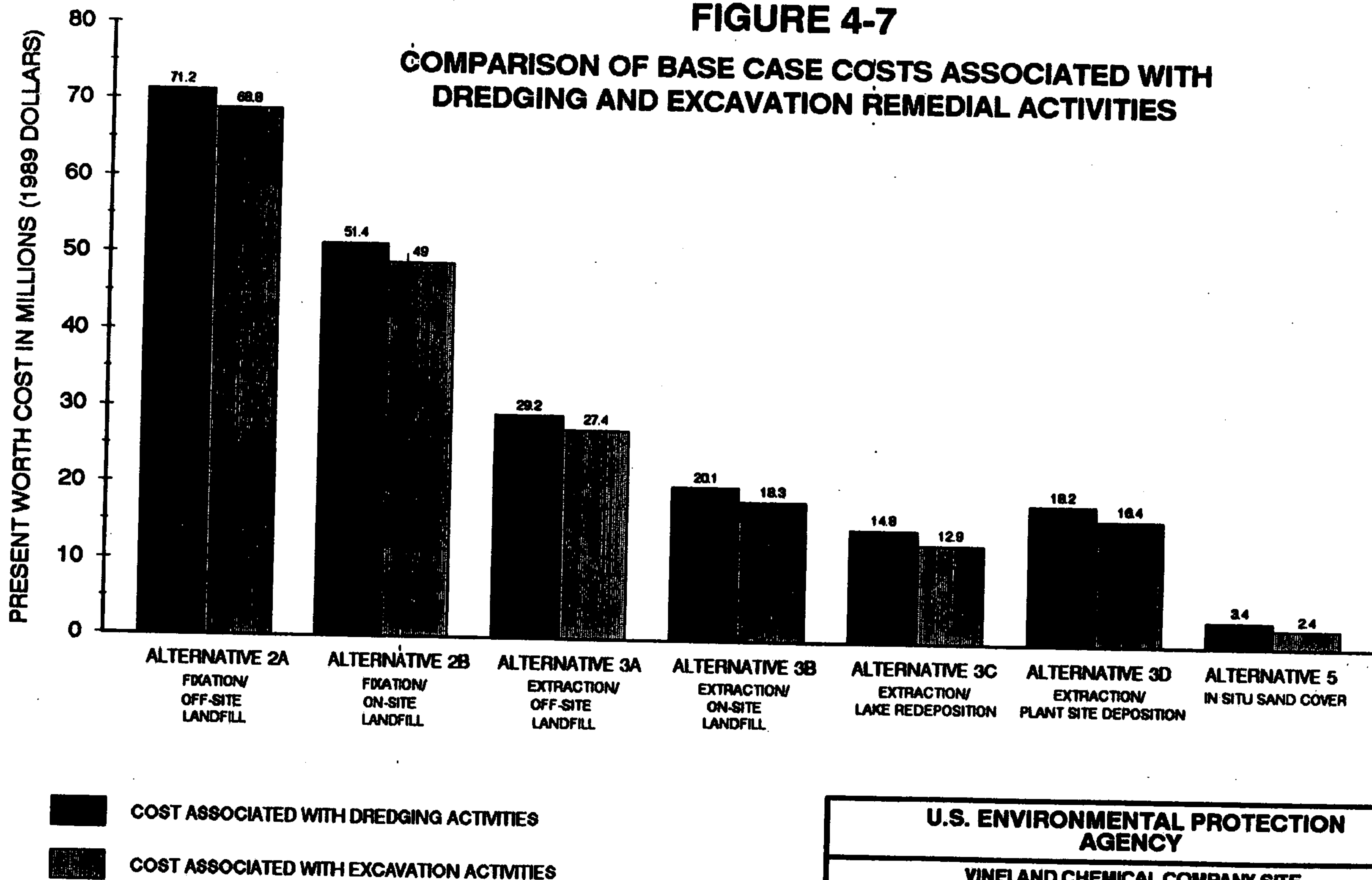
ALT	CAPITAL COST			ANNUAL O&M		PRESENT WORTH
	DIRECT	INDIRECT	TOTAL	LONG TERM	SHORT TERM	
1	$35,000	$9,450	$44,450	$49,455		$874,245
2A	$27,237,097	$7,354,016	$34,591,114	$13,020	$20,562,475	$71,246,971
2B	$10,820,246	$2,921,466	$13,741,713	$89,530	$20,562,475	$51,413,566
3A	$20,268,107	$5,472,389	$25,740,496	$13,020	$1,832,012	$29,227,193
3B	$12,611,824	$3,405,192	$16,017,016	$60,398	$1,832,012	$20,132,854
3C	$8,870,451	$2,395,022	$11,265,473	$13,020	$1,832,012	$14,752,170
3D	$11,610,914	$3,134,947	$14,745,861	$13,020	$1,832,012	$18,232,558
5	$2,476,276	$668,594	$3,144,870	$13,020		$3,368,883

TABLE 4-6

SUMMARY OF COST ANALYSIS (1989 DOLLARS)
(EXCAVATION CASE)

ALT	CAPITAL COST			ANNUAL O&M		PRESENT WORTH
	DIRECT	INDIRECT	TOTAL	LONG TERM	SHORT TERM	
2A	$25,446,160	$6,870,463	$32,316,623	$13,020	$20,487,428	$68,839,581
2B	$9,029,350	$2,437,925	$11,467,275	$89,530	$20,487,428	$49,006,227
3A	$18,876,051	$5,096,534	$23,972,585	$13,020	$1,808,043	$27,416,835
3B	$11,219,788	$3,029,343	$14,249,130	$60,397	$1,808,043	$18,322,520
3C	$7,478,424	$2,019,174	$9,497,598	$13,020	$1,808,043	$12,941,849
3D	$10,218,882	$2,759,098	$12,977,980	$13,020	$1,808,043	$16,422,231
5	$1,713,651	$462,686	$2,176,336	$13,020		$2,400,349

FIGURE 4-7
COMPARISON OF BASE CASE COSTS ASSOCIATED WITH DREDGING AND EXCAVATION REMEDIAL ACTIVITIES



** NOTE: VOLUMES OF SEDIMENT BASED UPON QUANTITIES IN BOTH ACCESSIBLE AND INACCESSIBLE AREAS WHEN THE LAKE IS AT ITS FULL CONDITION

U.S. ENVIRONMENTAL PROTECTION AGENCY
VINELAND CHEMICAL COMPANY SITE
FIGURE 4-7 COMPARISON OF BASE CASE COSTS ASSOCIATED WITH BOTH LAKE REMEDIATION SCENARIOS
EBASCO SERVICES INCORPORATED

LAKESUM

Hydraulic dredging activities in the lacustrine areas would require appropriate preventive measures to minimize resuspension, erosion and dissolved oxygen depletion in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10. The Clean Water Act Section 404 requires that no activity affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. Dry excavation when the lake is at drawdown would have less impact and would therefore be favored relative to this ARAR. Preventive measures to minimize erosion would be taken in order to comply with the ARAR. Alternatives 2A, 2B, 3A, 3B, 3C, and 3D would remove contaminants from the lake with minimal disturbance to the wetland. After the completion of the remediation, any wetlands that have been disturbed would be restored to their original conditions with minimal impact on them.

The U.S. Fish and Wildlife Coordination Act requires that the appropriate agency exercising jurisdiction over wildlife resources, and the U.S. Fish and Wildlife Service, must be consulted before undertaking any action that modifies a body of water. Special attention must be given to the impact on wetlands and floodplains (lake shore) in accordance with executive order 11990 and 11888. This is not applicable to Alternative 1 because it does not modify a water body in any way. Alternatives 2A, 2B, 3A, 3B, 3C, 3D, and 5 would be expected to comply with this regulation if implemented.

All alternatives would have to comply with RCRA facility standards and OSHA industry standards and regulations concerning hazardous wastes. RCRA 40 CFR 261 and 262 are applicable to activities including dredging hazardous sediments, transferring these materials to a treatment facility, and removing hazardous materials through a fixation process (Alternatives 2A and 2B) or a two-stage water extraction process (Alternatives 3A, 3B, 3C and 3D). Alternative 1 would not be subject to these ARARs because this alternative would not remove or contain any contaminated sediments.

RCRA LDRs restrict the placement of wastes into land disposal facilities. The fixated and extracted wastes are expected to be delistable as discussed in Section 3.0. The treated sediments could thus be safely disposed in a nonhazardous facility. In addition, if delisted, the extracted sediments could be deposited in Union Lake or on the plant site in accordance with the LDRs. As Alternative 1 and 5 do not involve any removal of the contaminated sediments, RCRA LDRs are not applicable to these alternatives.

Treatment of the wastewaters generated from Alternatives 2A, 2B, if dredging is implemented and Alternatives 3A, 3B, 3C, and 3D are expected to meet NJPDES permit requirements. A NJPDES permit would not be required for on-site discharge, but the permit conditions regarding arsenic concentration (0.05 mg/l) would be met. The treated effluent would also meet the New Jersey Surface Water Quality Standards in terms of arsenic (0.05 mg/l) and other conventional parameters (such as suspended solids, pH and DO). Alternatives 2A, 2B, if dredging is implemented, and Alternatives 3A, 3B, 3C, and 3D would treat the dredged supernatant/extractant for suspended solids and arsenic removal and the effluent would then be discharged back to the lake. The disposal of the supernatant would comply with the USEPA guidelines for disposal of dredged or fill material (40 CFR 280) by restoring and maintaining the chemical, physical and biological integrity of river water in accordance with the Clean Water Act (CWA Section 401).

The treated sediments would meet delisting requirements and be considered nonhazardous. DOT regulations for transporting nonhazardous solid wastes would pertain to all of the treatment alternatives. DOT rules for transporting hazardous waste would not be applicable to Alternatives 2A and 2B. However, the extraction alternatives, Alternative 3A, 3B, 3C, and 3D produce an arsenic-contaminated sludge that would be transported to a RCRA facility for treatment and disposal. Transport of the sludges would be in accordance with DOT rules. For all the alternatives involving off-site disposal the Clean Air Act and National Ambient Air Quality Standards would be applicable in regulating particulate air emission arising from handling and transporting the stabilized materials. Adequate dust-suppression measures would be provided for any potential fugitive dust emissions. These considerations may not apply to Alternatives 2B and 3B, as treated soils are disposed of at an on-site landfill. Alternatives 1 and 5 do not involve any treatment or transportation; therefore these ARARs would not apply.

The New Jersey Solid Waste Regulation (NJAC 7:26), particularly Subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfills (May 5, 1986), would be considered in managing treated nonhazardous wastes for both on-site and off-site landfills under Alternatives 2A, 2B and 3A or 3B.

At the start of remedial design for any of the alternatives, a Stage IA Survey, consisting of a comprehensive literature search, would be conducted according to the National Historic Preservation Act.

4.3.7 Overall Protection of Human Health and the Environment

Alternative 1 would entail no removal, containment or treatment of the contamination source. It would not contribute to the protection of human health and the environment since there would not be any reduction in the toxicity, mobility or volume o^ contaminants. Some years would be required for natural attenua tion to reduce sediment arsenic contamination in the lake t below the more stringent cleanup criterion of 20 mg/kg. Thi alternative is not considered responsive to the remedial objec tives, but provides a "base case" for comparison among othe alternatives.

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Alternatives 2A, 2B, 3A, 3B, 3C, and 3D involve actual removal and treatment of the contaminated sediments identified as a public health threat (chemical fixation for Alternatives 2A and 2B and chemical extraction for Alternatives 3A, 3B, 3C, and 3D) to affect permanent immobilization or extraction of arsenic compounds. These alternatives remove the contaminated source, and assuming that there is no significant redistribution of the remaining contaminated sediments and that the contaminated groundwater entering the lake from the ViChem site is controlled, protection of human health and the environment would be achieved. Fixation and extraction processes would prevent future releases of arsenic into the environment. Alternatives 2A, 2B, 3A and 3B would contain treated sediments in a nonhazardous landfill, minimizing the chances of further exposure to the contaminants. Alternative 3C and 3D would deposit the treated sediments in portions of Union Lake and on the plant site, respectively. These clean sediments would not pose a risk to public health. Treated sediments can be classified as nonhazardous and pose little or no risk to groundwater or surface water quality. The removal of contaminated sediments in Alternatives 2A, 2B, 3A, 3B, 3C, and 3D would attain the cleanup criterion in areas posing a public health risk and reduce the sediment ingestion cancer risk level to the target level of $2x10^{-6}$ in the more accessible areas of the lake and $1x10^{-5}$ in the less accessible areas. Alternative 5 would sufficiently isolate the sediments and also reduce the cancer risk level via sediment ingestion to the target level. It is assumed that shortly after the implementation of measures for the successful management of groundwater migration at the ViChem facility, and completion of remedial activities in the river and lake areas, the lake risks would be sharply reduced.

Any remaining contaminated sediments in the lake are not considered accessible and therefore are not deemed as a public health risk.

State Acceptance

This FS addresses several major comments that the State had to the FS, namely:

- o Consideration of the remediation to be conducted when the lake is at its full condition and when the lake is at draw down; and
- o Additional sampling prior to the initiation of the remedial alternative to confirm the location of those sediments to be treated.

In addition, each specific comment raised by the NJDEP to the FS has been responded to by the USEPA in a letter to the NJDEP.

Community Acceptance

No public comments have been received to date.

4.4 SUMMARY OF DETAILED ANALYSIS

Table 4-7 summarizes the alternative analysis discussed in the previous sections. A brief description of the key points in each of the nine evaluation criteria is presented.

In addition to the previous discussions, several other factors should be considered when selecting a remedial alternative for Union Lake. These factors are listed below:

- The source of arsenic into Union Lake is the groundwater discharge from the ViChem plant. The data suggests that eliminating this source should improve the downstream surface water quality. Therefore this source should be eliminated before any downstream remedial actions are taken.

- The Maurice River contains substantial quantities of arsenic in the sediments, which may need to be remediated. It would be prudent to initiate sediment remedial actions in the rivers before remediating sediments in Union Lake. Contaminated river sediments may migrate downstream into Union Lake.

- Extraction and fixation were seen as feasible remedial technologies for the soils on the ViChem site. They may also be feasible for the contaminated sediments in the Maurice River. Therefore, it may be more cost-effective to combine remedial actions in the various areas so that only one treatment system, for example, landfill, is constructed to remediate a given problem.

TABLE 4-7

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1 - No Action	Alternative 2A-Removal/ Fixation/Off-Site Nonhazardous Landfill	Alternative 2B-Removal/ Fixation/On-Site Nonhazardous Landfill	Alternative 3A-Removal/ Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
Key Components	Limiting access to site, public education programs, Site-use restrictions, Long-term monitoring.	Hydraulic dredging or excavattion, sediment fixation, Waste water treatment, off-site nonhazardous landfill, long-term monitoring.	Hydraulic dredging or excavation, sediment fixation, wastewater treatment, on-site nonhazardous landfill, long-term monitoring.	Hydraulic dredging, sediment extraction, wastewater treatment, sediments to off-site nonhazardous landfill, off-site hazardous sludge disposal, long-term monitoring.
Short-Term Effectiveness				
-Protection of community during remedial actions	No short-term threats to communities.	Potential for direct contact of spilled waste and inhalation of fugitive dust.	Same as Alternative 2A	Potential for direct contact of spilled waste and inhalation of fugitive dust.
-Protection of workers during remediation	Personnel protection equipment required against dermal contact and inhalation during sign posting, sample collection, inspection.	Minimal risk to workers. Personnel protection equipment required against direct contact with wastes and inhalation of fugitive dust	Same as Alternative 2A	Minimal risk to workers. Personnel protection equipment required to protect against direct contact with wastes and inhalation of fugitive dust.
-Environmental Impacts	No significant adverse environmental impacts from site activities.	Increased traffic, noise, and air pollution.	Minimal increase in traffic, noise and air pollution.	Increased traffic, noise, and air pollution.
		Hydraulic dredging may result in localized resuspension of sediments. Migration of suspended particulates could be controlled by increasing the water intake of the dredge and utilizing silt curtains.	Same as Alternative 2A.	Hydraulic dredging may result in localized resuspension of sediments. Migration of suspended particulates could be controlled by increasing the water intake of the dredge and utilizing silt curtains.
		Excavation of the exposed sediments would pose minimal impacts.	Same as Alternative 2A.	Excavation of the exposed sediment would pose minimal environmental impacts.
-Time until remediation	Some years.	Estimated to be 3 years from start of construction to completion of remediation work.	Same as Alternative 2A.	Estimated to be 3 years from start of construction to completion of remediation work.

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3B-Removal/ Extraction/Sediment to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal	Alternative 3C-Removal/ Extraction/Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal	Alternative 3D-Removal/Extraction/ Plant Site Deposition of Sediments/Off-Site Hazardous Sludge Disposal	Alternative 5-In Situ Sand Covering
Key Components	Hydraulic dredging, sediment extraction, wastewater treatment, sediments to nonhazardous landfill, off-site hazardous sludge disposal, long-term monitoring.	Hydraulic dredging, sediment extraction, wastewater treatment, lake deposition of sediments, off-site hazardous sludge disposal, long-term monitoring.	Hydraulic dredging or excavation, extraction, wastewater treatment, plant site deposition of sediments, off-site hazardous sludge disposal, long-term monitoring.	In-situ sand covering, long-term monitoring.
Short-Term Effectiveness				
-Protection of community during remedial actions	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Protection of workers during remediation	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Environmental Impacts	Minimal increase in traffic noise and air pollution. Same as Alternative 3A.	Same as Alternative 3B. Temporary adverse impacts such as resuspension of sediments may occur as a result of dredging and/or redeposition of treated material. Migration of suspended particulates could be controlled by increasing the water intake of the dredge and utilizing silt curtains.	Same as Alternative 3A.	If remediation is conducted when the lake is at its full condition discharge of the sand covering could result in temporary adverse impacts such as resuspension of sediment.
	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	
-Time until remediation	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Estimated to be 1 year from start of remediation to finish.

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A
Long-Term Effectiveness				
-Magnitude of Residual Risks	Long-term evaluation required for natural degradation and transport reduction.	Sediments identified as a public health risk would be removed and treated. Redistribution of contaminated sediments could result in a public health risk. Treated sediments delistable as non hazardous waste. Supernatant water treated to NJPDES.	Same as Alternative 2A. On-site landfill maintenance and monitoring required.	Sediment identified as a public health risk would be removed and treated. Redistribution of contaminated sediments could result in a public health risk. Treated sediments delistable as nonhazardous waste. Supernatant water treated to NJPDES.
-Adequacy of Control	Depends on success in preventing access to the site.	Proven technologies. Long term monitoring program required for remaining sediment.	Same as Alternative 2A. Long-term maintenance required for on-site landfill facility.	Proven Technology. Long-term monitoring program required for remaining sediments.
-Reliability of Controls	Migration of contaminants from sediments to water could occur.	Excavation of the exposed sediments when the lake is at drawdown would offer more control of operations than dredging.	Same as Alternative 2A.	Excavation of exposed sediments when the lake is at drawdown would offer more control of operations than dredging.
		If significant redistribution of sediments, additional remedial actions may be required.	Same as Alternative 2A. Minimal failure of on-site landfill facility.	If significant redistribution of sediments occurs, additional remedial actions may be required.
Reduction of Toxicity, Mobility or Volume				
-Treatment Process and Remedy	No reduction of toxicity, mobility or volume.	Reduction in mobility of treated sediment and slight reduction in volume of on-site sediments. Increase in volume and weight of treated sediments. No reduction in toxicity.	Same as Alternative 2A.	Permanent reduction in toxicity of treated sediments. Slight reduction in volume and mobility of on-site contaminants.
-Amount of Hazardous Materials Remaining	No material removed or treated.	Sediments identified as a public health risk are removed and treated to be delistable. Remaining sediments are not considered accessible for sediment ingestion pathway.	Same as Alternative 2A.	Sediments identified as a public health risk are removed and treated to be delistable. Remaining sediments are not considered accessible for sediment ingestion pathway. Significant quantity of arsenic contaminated sludge generated from extraction process.

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3B	Alternative 3C	Alternative 3D	Alternative 5
Long Term-Effectiveness				
-Magnitude of Residual Risks	Same as Alternative 3A. Long-term maintenance and monitoring required for on-site landfill.	Same as Alternative 3A. Sediment arsenic concentration would be reduced to below 20 mg/kg.	Same as Alternative 3C.	Contaminated sediments above action level would remain on-site. Sediment redistribution to top of sand cover could result in a public health risk.
-Adequacy of Control	Same as Alternative 3A. Long-term maintenance required for on-site landfill facility.	Same as Alternative 3A.	Same as Alternative 3A.	Long-term maintenance of sand cover would be required. Additional cover or regrading of cover may be necessary. Long-term monitoring required for remaining sediments.
-Reliability of Controls	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	N/A
	Same as Alternative 3A. Minimal risk of failure of on-site landfill facility.	Same as Alternative 3A. Minimal potential of leachate from delisted sediments deposited in lake.	Same as Alternative 3A. Minimal potential of leachate from delisted sediments deposited on the plant site.	Reliability of sand cover to prevent ingestion of sediments unknown. Significant long-term maintenance of cover required to prevent exposure of sediments.
Reduction in Toxicity, Mobility or Volume				
-Treatment Process and Remedy	Same as Alternative 3A.	Same as Alternative 3A. Reduction in toxicity and mobility of sediments.	Same as Alternative 3A.	No reduction in toxicity or volume of waste. Arsenic mobility would be reduced. Contaminated sediments left uncovered may redistribute to areas of potential public risk.
-Amount of Hazardous Material Remaining	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	All material remaining in place.

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A
Reduction of Toxicity, Mobility, or Volume (Cont')				
-Irreversibility of Treatment	N/A	Treatment is essentially irreversible.	Same as Alternative 2A.	Treatment is essentially irreversible.
-Type and Quantity of Residual Waste	N/A	Treated waste expected to be delistable.	Same as Alternative 2A.	Treated waste expected to be delistable. Arsenic sludge generated from extraction process highly contaminated.
Implementability				
o Technical Feasibility				
- Ability to Construct Technology	No difficulty.	Standard equipment. Commercially available.	Same as Alternative 2A.	Standard equipment commercially available.
- Reliability of Technology	No technology.	Well developed and proven technology. Pilot scale studies required to optimize treatment. Excavation of exposed sediment would be more reliable than hydraulic dredging due to an increase in operational control.	Same as Alternative 2A.	Well developed and proven technology. Pilot scale studies required to optimize treatment. Excavation or exposed sediment would be more reliable than hydraulic dredging due to an increase in operational control.
- Ease of Undertaking Additional Remediation, If Necessary		Would be relatively simple to undertake additional remediation.	Same as Alternative 2A.	Additional future remedial actions may be required.
- Monitoring Considerations	Long-term monitoring required. Monitoring analysis techniques available.	Long-term monitoring required.	Long-term monitoring for on-site landfill and remaining sediment required. Monitoring analysis techniques available.	Long-term monitoring required.
		Monitoring would be required throughout the remediation to ensure the removal of the sediments identified as a potential public health risk.	Same as Alternative 2A.	Monitoring would be required throughout the remediation to ensure the removal of the sediments identified as a potential public health risk.

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TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3B	Alternative 3C	Alternative 3D	Alternative 5
Reduction of Toxicity, Mobility, or Volume (Cont')				
-Irreversibility of The Treatment	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	No treatment.
-Type and Quantity of Residual Waste	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	No treatment.
Implementability				
o Technical Feasibility				
-Ability to Construct	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Standard equipment and material.
-Reliability of Technology	Same as Alternative 3A.	Same as Alternative 3A. Reliability of lake deposition of delisted sediments is high.	Same as Alternative 3A. Reliability of plant site deposition is high.	Reliability of effectiveness of sand cover is unknown. Expected to be fairly good.
	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Ease of Undertaking Additional Remediation, If Necessary	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Monitoring Considerations	Same as Alternative 3A. Long-term monitoring for on-site landfill required. Monitoring analysis techniques available.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A
o **Administrative Feasibility**				
-Ability to Obtain Approvals	Permits not required.	Delisting approval required from NJDEP.	Delisting approval required from USEPA Region II. As the site is a CERCLA site, permits for on-site landfill are not required.	Delisting approval required from NJDEP
-Coordination with Other Agencies	Coordination required.	Coordination required.	Intensive coordination required for on-site landfill facility.	Coordination required for identification of off-site nonhazardous landfill and off-site hazardous treatment and disposal facility.
-**Availability of Services and Materials**				
-Availability of Treatment Capacity and Disposal Services	Not required.	Treatment capacity and storage capacity are all adequately available. Off-site landfill requires administrative acquisition.	Same as Alternative 2A. On-site landfill provides higher availability for disposal.	Treatment capacity and storage are all adequately available. Off-site nonhazardous landfill requires administrative acquisition.
-Availability of Necessary Equipment and Specialists	Not required.	Standard equipment and operations. No specialists required.	Same as Alternative 2A.	Standard equipment and operations. No specialties required.
-Availability of Prospective Technologies	Not required.	Prospective technologies are available. Technologies are proven in Bench-Scale Tests. Pilot studies would be required to optimize process.	Same as Alternative 2A.	Prospective technologies are available. Technologies are proven in Bench-Scale Studies. Pilot-Scale studies required to optimize process.
Cost				
Lake At Its Full Condition				
o Total Capital Cost	$ 44,450	$ 34,591,000	$13,742,000	$ 25,740,000
o Annual Operation and Maintenance Cost	$ 49,455	$ 13,000 Long-term $ 20,562,000 Short-term	$ 90,000 Long-term $20,562,000 Short-term	$ 13,000 Long-Term $ 1,832,000 Short-Term
o Present Worth	$874,245	$ 71,247,000	$51,414,000	$ 29,227,000
Lake At Drawdown Condition				
o Total Capital Cost	Same as Above	$ 32,317,000	$11,467,000	$ 23,973,000
o Annual Operation and	Same as Above	$ 13,000 Long-term $ 20,487,000 Short-term	$ 90,000 Long-term $20,487,000 Short-Term	$ 13,000 Long-Term $ 1,808,000 Short-Term
	me as Above	$ 68,840,000	$49,006,000	$ 27,417,000

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3B	Alternative 3C	Alternative 3D	Alternative 5
o Administrative Feasibility				
-Ability to obtain Approvals	Delisting approval required from USEPA Region II. As the site is a CERCLA site, permits for landfill are not required.	Same as Alternative 3A. Approval for lake deposition may be difficult to obtain.	Same as Alternative 3A. Approval for plant site deposition may be difficult to obtain.	Should not pose a problem.
-Coordination with Other Agencies	Intensive coordination required for on-site landfill facility and identification of off-site hazardous treatment and disposal facility.	Intensive coordination required for approval of lake deposition and identification of hazardous treatment and disposal facility.	Coordination required for approval of plant site deposition and identification of off-site hazardous treatment and disposal facility.	Coordination required.
-Availability of Services and Materials				
-Availability of Treatment Capacity and Disposal Services	Same as Alternative 3A. On-site nonhazardous landfill provides higher availability or disposal.	Treatment capacity, storage capacity and disposal capacity are all adequately available.	Same as Alternative 3C.	No treatment or disposal.
-Availability of Necessary Equipment and Specialists	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Availability of Prospective Technologies	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Not required.
Costs Lake At Its Full Condition				
o Total Capital Cost	$16,017,000	$11,265,000	$14,746,000	$ 3,145,000
o Annual Operation & Maintenance Cost	$ 60,000 Long-term $ 1,832,000 Short-term	$ 13,000 Long-term $ 1,832,000 Short-term	$ 13,000 Long-Term $ 1,832,000 Short-Term	$ 13,000
o Present Worth	$20,133,000	$14,752,000	$18,233,000	$ 3,369,000
Lake At Drawdown Condition				
o Total Capital Cost	$14,249,000	$ 9,498,000	$12,978,000	$ 2,176,000
	$ 60,000 Long-term $ 1,808,000 Short-term	$ 13,000 Long-term $ 1,808,000 Short-term	$ 13,000 Long-Term $ 1,808,000 Short-Term	$ 13,000
	$18,323,000	$12,942,000	$16,422,000	$ 2,400,000

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A
Compliance with ARARs				
-Compliance with contaminant-specific ARARs health	No contaminant-specific ARARs established for arsenic contaminated sediment. Will not meet health based levels.	No contaminant-specific ARARs established for arsenic contaminated sediments. Will meet health based levels.	Same as Alternative 2A.	No contaminant-specific ARARs established for arsenic. Treated sediment will meet based levels.
-Appropriateness of waivers	Not justifiable.	Treatability variance may be required.	Same as Alternative 2A.	Treatability variance may be required.
-Compliance with action-specific ARARs	All appropriate and relevant RCRA closure/post-closure requirements in 40 CFR 264, 110-264, 120 would not be met.	All action-specific ARARs would be met.	Same as Alternative 2A.	All action-specific ARARs will be met.
-Compliance with appropriate criteria, advisories, and guidance	Not in compliance with state and local criteria and federal advisories.	Would be in compliance with state and local criteria and federal advisories.	Same as Alternative 2A.	Will be in compliance with state and local criteria and federal advisories.
Overall Protection of Human Health and the Environment	Risk of direct contact with contaminated sediment and water controlled but not eliminated. Contaminants remain on-site and their toxicity, mobility or volume unaltered. Cancer risk greater than 2×10^{-6} level.	Risk of sediment ingestion reduced. Contaminants removed and chemically fixated to reduce mobility. Volume of fixated solids will increase by 17%. Cancer risk levels for those sediments identified as a public health risk reduced to target levels.	Same as Alternative 2A.	Risk of sediment ingestion reduced. Contaminants removed and converted to nonhazardous form. Volume of contaminants slightly reduced. Cancer risk level for those sediments identified as a public health risk reduced to target levels.
State Acceptance	State comments indicated that the no action alternative would be protective of human health through the restricted access to the lake.	General comments received from the State include the need for sampling prior to the initiation of the action to confirm the location of the contaminated sediments.	Same as Alternative 2B.	General comments received from the state include the need for sampling prior to the initiation of the action to confirm the location of the contaminated sediments.
Community Acceptance	No public comments have been received to date.	Same as Alternative 1.	Same as Alternative 1.	No public comments received to date.

TABLE 4-7 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3B	Alternative 3C	Alternative 3D	Alternative 5
Compliance with ARARs				
-Compliance with contaminant-specific. ARARs	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Will not meet health based level.
-Appropriateness of waivers	Same as Alternative 3A.	Treatability variance may be required.	Same as Alternative 3A.	Not required.
-Compliance with action-specific ARARs	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Compliance with appropriate criteria, advisories, and guidance	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
Overall Protection of Human Health and the Environment	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Risk of sediment ingestion reduced. Mobility of contaminants reduced. Cancer risk level for those sediments identified as a public health risk reduced to target levels. These contaminants remain on-site.
State Acceptance	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
Community Acceptance	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.

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APPENDIX A

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APPENDIX A

BREAKDOWN OF MAJOR FACILITIES

AND

CONSTRUCTION COMPONENTS FOR REMEDIAL ALTERNATIVES

TABLE A-1

ALTERNATIVE 1 - NO ACTION
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/Construction	Estimated Quantities	Description
1. Posting of Warning Signs	75	14 ft x 3 ft PVC signs on 6 ft posts along lake perimeter located approximately 500 ft apart.
2. Public Awareness Program	2	1 public meeting and 1 public workshop

TABLE A-2

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION		
1. Parking Area (included in 2.)		
2. Equipment Parking and Storage Area	100 ft x 100 ft	1 ft thick crushed stone pavement.
3. Security Fence & Gate	1,000 ft	8 ft high, all metal, 45° inclined barbed wire, double frame gate, each 12 ft wide, 8 ft high.
4. Access Road	3,000 ft x 25 ft	1 ft thick crushed stone and drain ditch.
II. SUPPORT FACILITIES	5 trailers	Trailers for a) EPA/DEP Office b) Engineer Office c) Health/Safety (Decontamination Equipment) d) Contractor Office e) Contractor's Equipment.
III. SEDIMENT HYDRAULIC DREDGING*	450,598 cy	Dredge sediments to 1.0 ft depth over 81 acres using two units of "Mudcat" dredge Model MC-915 @ 50 in place cy/hr each with one common pontooned floating pipeline to treatment plant. Dredging produces 20% solids by weight. Cost includes silt curtains and other temporary controls.
III. SEDIMENT EXCAVATION**	80,285 cy	Excavation of floodplain sediments of 55 volume % solids.
IV. CLEAN BACKFILL	80,285 cy	Clean fill used to replace dredged and excavated material.
V. HOLDING TANKS & MIXERS	2	Two 120,000 gallon steel tanks with mixers.
VI. SEDIMENT THICKENING SYSTEM		
1. Separator	1	14-6 in. soft rubber lined hydroclones mounted in parallel. 7 operating, 7 stand-by.
2. Slurry Pump	2	500 gpm each, diaphragm pumps. 1 operating, 1 standby.
VII. SUPERNATANT TREATMENT SYSTEM		
1. Coagulator - Clarifier	2	Two 20 ft diameter coagulator - clarifiers, steel tank, 10 ft sidewall depth, bottom slope 3 in./ft, built on-site, heavy duty rake mechanism, with rapid mixing, coagulation/flocculation and sedimentation chambers.

TABLE A-2 (Cont'd)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
VII. SUPERNATANT TREATMENT SYSTEM (Cont'd)		
2. Sludge Pumps	2	10 gpm each, diaphragm pumps.
3. Coagulant Feeding Pump	2	Metering pumps, each 60 gph, stainless steel 316.
4. Coagulant Day Tank	1	500 gal day tank, fiberglass reinforced polyester with one mixer.
5. Polymer Feeding Pump	2	Metering pumps, each 20 gph, stainless steel 316.
6. Polymer Day Tank	1	200 gal day tank, fiberglass reinforced polyester with one mixer.
7. Ferric Chloride Feeding Pump	2	Metering pumps, each 60 gph, stainless steel 316.
8. Ferric Chloride Day Tank	1	500 gal day tank, fiberglass reinforced polyester with one mixer.
VIII. CHEMICAL FIXATION SYSTEM		
1. Slurry Mixing Tank	2	3,500 gal steel tanks, each with 20 min mixing time.
2. Mixers	2	Turbine impellers with 6 ft flat blades.
3. Chemical Tank (K-20 LSC)	1	3,000 gal steel tank with one mixer (one week storage).
4. Chemical Feeding Pump	2	Metering pumps, each 60 gph, stainless steel 316.
5. Carbon Powder Silo	1	3,000 gal steel tank (one week storage) elevated steel structure support.
6. Carbon Powder Feeding System	2	Adjustable 25 lb/min loss in weight type dry feeder each.
7. Portland Cement Silo	1	80,000 gal steel tank (one week storage tank), elevated steel structure support.
8. Portland Cement Feeding System	2	Adjustable 400 lb/min loss in weight type dry feeder each.
9. Fly Ash Silo	1	20,000 gal steel tank (one week storage tank), elevated steel structure support.

TABLE A-2 (Cont'd)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
VIII. CHEMICAL FIXATION SYSTEM (Cont'd)		
10. Fly Ash Feeding System	2	Adjustable 100 lb/min loss in weight type dry feeder each.
11. Sludge Pump	2	150 gpm diaphragm pump. 1 operating, 1 standby.
12. Process Water Delivery System	1	Includes tank, pump, piping, and high pressure water system.
13. Sediment Belt Conveyor and Hopper**	2	Double vibrating screen hopper 45° belt is completely enclosed and capable of reaching 25 ft elevation.
IX. FIXATED SEDIMENT CURING SYSTEM		
1. Curing Basin Dike	600 ft	Top width = 3 ft, slope = 1:3, height = 2 ft bottom width = 15 ft, basin area = 150 ft x 150 ft
2. Clay Layer	850 cy	Local clay with 1 x 10^{-7} cm/sec permeability, 1 ft thick, 22,500 ft^2.
X. OFF-SITE NONHAZARDOUS LANDFILL	210,874 ton	Trucked to nonhazardous landfill facilities (within 100 miles from Union Lake), 480 ton/day.
XI. PROCESS PIPING AND I&C		For the above treatment facilities
XII. ELECTRICAL		For the above treatment facilities
XIII. BUILDINGS, PLATFORMS & STAIRS		For the above treatment facilities
XIV. FOUNDATIONS & PADS		For the above treatment facilities

* Applicable only if remediation occurs when the lake is at its full condition.
** Applicable only if remediation occurs when the lake is at its drawdown condition.

TABLE A-3

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SUPPORT FACILITIES	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT HYDRAULIC DREDGING*/ SEDIMENT EXCAVATION**	Same as Alt. 2A, Item III	Same as Alt. 2A, Item III
IV. CLEAN BACKFILL	Same as Alt. 2A, Item IV	Same as Alt. 2A, Item IV
V. HOLDING TANKS	Same as Alt. 2A, Item V	Same as Alt. 2A, Item V
VI. SEDIMENT THICKENING SYSTEM*	Same as Alt. 2A, Item VI	Same as Alt. 2A, Item VI
VII. SUPERNATANT TREATMENT SYSTEM*	Same as Alt. 2A, Item VII	Same as Alt. 2A, Item VII
VIII. CHEMICAL FIXATION SYSTEM	Same as Alt. 2A, Item VIII	Same as Alt. 2A, Item VIII
IX. FIXATED SEDIMENT CURING SYSTEM	Same as Alt. 2A, Item IX	Same as Alt. 2A, Item IX
X. ON-SITE HAZARDOUS LANDFILL		
1. Liner System		
o Clay Layer	26,277 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Synthetic Liner	349,546 sf	40 mil high density polyethylene (HDPE)
o Geotextile Cloth	328,957 sf	Polypropylene cloth to allow filtration of leachate into sand layer
o Leachate Collection System		
- PVC Pipe	3,495 ft	4 in. dia perforated
- RC Sump	2	4 ft dia 6 ft deep
- Pumps	2	25 gpm each, chemical resistant
o Sand Layer	25,128 cy	2 ft thick sand layer
2. Fixated Sediment Hauling, Deposition and Compaction	116,542 cy	264 cy/day
3. Capping System		
o Clay Layer	25,164 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Geotextile Cloth	239,868 sf	Polypropylene cloth to allow filtration of leachate into drainage layer
o Drainage Layer	13,147 cy	1 ft thick sand layer
o Topsoil	27,356 cy	2 ft thick topsoil
o Vegetation (Grass Seeding)	7.86 acres	

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TABLE A-3 (Cont'd)

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/Construction	Estimated Quantities	Description
4. Drainage Ditch	3,408 ft	Top Width = 14 ft, Total Depth = 2 ft Side Slope = 3:1, Bottom Width = 2 ft
o Clay Layer	9,804 cy	2 ft thick clay (permeability = 10^{-7} cm/sec)
o Topsoil	3,266 cy	2 ft thick topsoil
o Vegetation (Grass Seeding)	0.86 acres	
XI. PROCESS PIPING AND I&C	Same as Alt. 2A, Item XI	Same as Alt. 2A, Item XI
XII. ELECTRICAL	Same as Alt. 2A, Item XII	Same as Alt. 2A, Item XII
XIII. BUILDINGS, PLATFORMS & STAIRS	Same as Alt. 2A, Item XIII	Same as Alt. 2A, Item XIII
XIV. FOUNDATIONS & PADS	Same as Alt. 2A, Item XIV	Same as Alt. 2A, Item XIV

TABLE A-4

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SUPPORT FACILITIES	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT HYDRAULIC DREDGING*/ SEDIMENT EXCAVATION**	Same as Alt. 2A, Item III	Same as Alt. 2A, Item III
IV. CLEAN BACKFILL	Same as Alt. 2A, Item IV	Same as Alt. 2A, Item IV
V. SEDIMENT EXTRACTION SYSTEM		
1. Primary Mixing Tank and Mixer	2	Two 120,000 gallon steel tanks with mixers.
2. Primary Separator	1	14-6 in. soft rubber lined hydroclones mounted in parallel. 7 operating, 7 on stand-by.
3. Primary Slurry Pump	2	500 gpm, diaphragm pumps. 1 operating, 1 standby.
4. Water Feeding Pump	2	Each 200 gpm, metering pumps
5. Piping	1,000 lf	6 in. dia. (insulated).
6. Secondary Mixing Tank and Mixer	2	Two 60,000 gallon steel tanks with mixers.
7. Secondary Separator	1	Same as above.
8. Secondary Slurry Pump	2	Each 500 gpm, diaphragm pumps. 1 operating, 1 standby.
9. Process Water Delivery System	1	Includes tank, pump, piping and high pressure water system.
10. Sediment Belt Conveyor and Hopper	2	Double vibrating screen hopper 45° belt is completely enclosed and capable of reaching 25 ft. elevation.
VI. EXTRACTANT TREATMENT SYSTEM		
1. Extractant Oxidation		
o Reactor Tank	2	Two 30 ft dia 12 ft sidewall reactor tanks, open top epoxy lined steel tank, 4 baffles - 90° apart, 12 ft deep, 1 ft wide, top to contain agitation mounting.

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TABLE A-4 (Cont'd)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
o Agitator	2	Two agitators, 2 - four pitch blade turbine impellers, top mounted, shaft 12 ft, stainless steel.
o Acid Feeder	2	Metering pumps, 40 gph, stainless steel.
o Acid Storage Tank	1	3,000 gal carbon steel, horizontal tank, rubber lined.
o Potassium Permanganate Silo	1	2,000 gal steel tank, elevated steel structure support.
o Potassium Permanganate Feeder	2	Each 1.0 lb/min adjustable, loss in weight type dry feeders.
2. Extractant Coagulation/Flocculation/ Precipitation		
o Coagulator - Clarifier	2	Each 48 ft dia coagulator/clarifier, 12 ft sidewall depth, bottom slope 3 in/ft, concrete bottom, steel tank epoxy lined, heavy duty rake mechanism.
o Sludge Pump	2	Four 10 gpm, diaphragm pumps.
o Water Pump	4	200 gpm, TDH = 25 ft, HP = 4.2
o Ferric Chloride Storage Tank	1	12 ft dia, 15 ft vertical, cone roof, steel bottom, carbon steel tank, rubber lined.
o Ferric Chloride Feeder	2	30 gph metering pumps, Teflon lined.
o Polymer Feeder	2	20 gph metering pump each, stainless steel 316.
o Polymer Day Tank	1	200 gal day tank, fiberglass reinforced polyester.
o Caustic Storage Tank	1	1,000 gal steel tank, rubber lined.
o Caustic Feeders	2	40 gph, metering pumps stainless steel 316.
VII. OFF-SITE NONHAZARDOUS DISPOSAL	105,830 ton	Trucked to nonhazardous landfill sites (within 100 miles from river), 150 ton/day.
VIII. OFF-SITE HAZARDOUS DISPOSAL	8,555 ton	Trucked to RCRA "C" landfill sites

TABLE A-4 (Cont'd)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
IX. PROCESS PIPING AND I&C		For the above treatment facilities
X. ELECTRICAL		For the above treatment facilities
XI. BUILDINGS, PLATFORMS & STAIRS		For the above treatment facilities
XII. FOUNDATIONS & PADS		For the above treatment facilities

TABLE A-5

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENTS TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SUPPORT FACILITIES	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT HYDRAULIC DREDGING*/ SEDIMENT EXCAVATION**	Same as Alt. 2A, Item III	Same as Alt. 2A, Item III
IV. CLEAN BACKFILL	Same as Alt. 3A, Item IV	Same as Alt. 3A, Item IV
V. SEDIMENT CHEMICAL EXTRACTION SYSTEM	Same as Alt. 3A, Item VI	Same as Alt. 3A, Item VI
VI. EXTRACTANT TREATMENT SYSTEM	Same as Alt. 3A, Item V	Same as Alt. 3A, Item V
VII. ON-SITE NONHAZARDOUS LANDFILL	Same as Alt. 3A, Item VI	Same as Alt. 3A, Item VI
1. Liner System		
o Clay Layer	16,505 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Synthetic Liner	219,297 sf	40 mil high density polyethylene (HDPE)
o Geotextile Cloth	205,387 sf	Polypropylene cloth to allow filtration of leachate into sand layer
o Leachate Collection System		
- PVC Pipe	2,193 ft	6 in. dia perforated
- RC Sump	2	4 ft dia, 5 ft deep
- Pumps	2	25 gpm each, chemical resistant
o Sand Layer	15,727 cy	2 ft thick sand layer
2. Extracted Sediment Hauling, Deposition and Compaction	70,528 cy	100 cy/day
3. Capping System		
o Clay Layer	15,589 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Geotextile Cloth	146,356 sf	Geotextile cloth to allow filtration of leachate into drain layer
o Drainage Layer	8,158 cy	1 ft thick sand layer
o Top Soil	16,999 cy	6 in. topsoil
o Vegetation	4.84 acres	

TABLE A-5 (Cont'd)

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENTS TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
VII. ON-SITE NONHAZARDOUS LANDFILL (Cont'd)		
4. Drainage Ditch	2,294 ft	Top Width - 20 ft, Total Depth = 2 ft Bottom Width - 2 ft, Side Slope - 2:1
o Clay Layer	6,601 cy	2 ft thick clay (permeability - 10^{-7} cm/sec)
o Topsoil	2,199 cy	2 ft thick topsoil
o Vegetation	0.58 acres	
VIII. OFF-SITE HAZARDOUS DISPOSAL	Same as Alt. 3A, Item VIII	Same as Alt. 3A, Item VIII
IX. PROCESS PIPING AND I&C	Same as Alt. 3A, Item IX	Same as Alt. 3A, Item IX
X. ELECTRICAL	Same as Alt. 3A, Item X	Same as Alt. 3A, Item X
XI. BUILDINGS, PLATFORMS AND STAIRS	Same as Alt. 3A, Item XI	Same as Alt. 3A, Item XI
XII. FOUNDATIONS AND PADS	Same as Alt. 3A, Item XII	Same as Alt. 3A, Item XII

TABLE A-6

ALTERNATIVE 3C - REMOVAL/EXTRACTION/DEEP LAKE DEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SUPPORT FACILITIES	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT HYDRAULIC DREDGING*/ SEDIMENT EXCAVATION**	Same as Alt. 3A, Item III	Same as Alt. 3A, Item III
IV. CLEAN BACKFILL	Same as Alt. 3A, Item IV	Same as Alt. 3A, Item IV
V. SEDIMENT EXTRACTION SYSTEM	Same as Alt. 3A, Item VI	Same as Alt. 3A, Item VI
VI. EXTRACTANT TREATMENT SYSTEM	Same as Alt. 3A, Item V	Same as Alt. 3A, Item V
VII. SEDIMENT REDEPOSITION	70,528 cy	Treated sediments deposited at a rate of 110 cy/day from dump trucks or barges
VIII. OFF-SITE HAZARDOUS DISPOSAL	Same as Alt. 3A, Item VIII	Same as Atl. 3A, Item VIII
IX. PROCESS PIPING I&C	Same as Alt. 3A, Item IX	Same as Alt. 3A, Item IX
X. ELECTRICAL	Same as Alt. 3A, Item X	Same as Alt. 3A, Item X
XI. BUILDINGS, PLATFORMS AND STAIRS	Same as Alt. 3A, Item XI	Same as Alt. 3A, Item XI
XII. FOUNDATIONS AND PADS	Same as Alt. 3A, Item XII	Same as Alt. 3A, Item XII

TABLE A-7

ALTERNATIVE 3D - REMOVAL/EXTRACTION/PLANT SITE DEPOSITION FOR SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SUPPORT FACILITIES	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT HYDRAULIC DREDGING*/ SEDIMENT EXCAVATION**	Same as Alt. 3A, Item III	Same as Alt. 3A, Item III
IV. CLEAN BACKFILL	Same as Alt. 3A, Item IV	Same as Alt. 3A, Item IV
V. SEDIMENT EXTRACTION SYSTEM	Same as Alt. 3A, Item VI	Same as Alt. 3A, Item VI
VI. EXTRACTANT TREATMENT SYSTEM	Same as Alt. 3A, Item V	Same as Alt. 3A, Item V
VII. PLANT SITE DEPOSITION		
1. Hauling/Deposition/Compaction/Grading	70,528 cy	Treated Sediments deposited on plant site
2. Topsoil	40,333 cy	One foot depth of topsoil placed above treated sediments
3. Vegetation	20 acres	Grass seeding
VIII. OFF-SITE HAZARDOUS DISPOSAL	Same as Atl. 3A, Item VIII	Same as Atl. 3A, Item VIII
IX. PROCESS PIPING I&C	Same as Alt. 3A, Item IX	Same as Alt. 3A, Item IX
X. ELECTRICAL	Same as Alt. 3A, Item X	Same as Alt. 3A, Item X
XI. BUILDINGS, PLATFORMS AND STAIRS	Same as Alt. 3A, Item XI	Same as Alt. 3A, Item XI
XII. FOUNDATIONS AND PADS	Same as Alt. 3A, Item XII	Same as Alt. 3A, Item XII

TABLE A-8

ALTERNATIVE 5 - IN SITU SAND COVERING
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. COARSE SAND COVER INSTALLATION	130,608 cy	Coarse sand to be trucked to site. Barges and/or bulldozers to deposit 1 ft layer of sand over contaminated sediments.

APPENDIX B

VIN 002 0495

TABLE B-1

ALTERNATIVE 1 - NO ACTION

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION, $		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. POSTING OF WARNING SIGNS	75	100.00	7,500	100.00	7,500	15,000
II. PUBLIC AWARENESS PROGRAM	2			10,000.00	20,000	20,000

Total Direct Construction Cost (TDCC)	35,000
Contingency @20% of TDCC	7,000
Engineering @5% of TDCC	1,750
Legal and Administrative @ 2% of TDCC	700
Total Construction Cost	44,450

TABLE B-2

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION						
1. Parking Area (included in 2.)						
2. Equipment Parking and Storage Area	1,110 sy	7.50	8,325	6.78	7,526	15,851
3. Security Fence and Gate	1,000 lf	17.60	17,600	33.15	33,150	50,750
4. Access Road	8,333 sy	11.70	97,496	14.94	124,495	221,991
						288,592
II. SUPPORT FACILITIES	5 trailers	15,600.00	78,000			78,000
III. SEDIMENT HYDRAULIC DREDGING	450,598 cy			5.76	2,595,442	2,595,442
IV. CLEAN BACKFILL	80,285 cy	10.00	802,852	4.54	364,495	1,167,347
V. HOLDING TANKS AND MIXERS	2	115,000.00	230,000	45,500.00	91,000	321,000
VI. SEDIMENT THICKENING SYSTEM						
1. Separator	1	63,000.00	63,000	10,000.00	10,000	73,000
2. Slurry Pump	2	17,600.00	35,200	5,900.00	11,800	47,000
						120,000

TABLE B-2 (Continued)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
VII. SUPERNATANT TREATMENT SYSTEM						
1. Coagulator - Clarifier	2	92,740.00	185,480	24,300.00	48,600	234,080
2. Sludge Pump	2	3,200.00	6,400	890.00	1,780	8,180
3. Coagulant Feeding Pump	2	1,900.00	3,800	510.00	1,020	4,820
4. Coagulant Day Tank	1	6,000.00	6,000	2,295.00	2,295	8,295
5. Polymer Feeding Pump	2	1,200.00	2,400	510.00	1,020	3,420
6. Polymer Day Tank	1	4,000.00	4,400	2,040.00	2,040	6,440
7. Ferric Chloride Feeding Pump	2	1,900.00	3,800	765.00	1,530	5,330
8. Ferric Chloride Day Tank	1	6,000.00	6,000	2,295.00	2,295	8,295
						278,860
VIII. CHEMICAL FIXATION SYSTEM						
1. Slurry Mixing Tank	2	10,970.00	21,940	4,210.00	8,420	30,360
2. Mixer	2		Included with Slurry Mixing Tank			
3. Chemical Tank (K-20 LSC)	1	10,000.00	10,000	3,825.00	3,825	13,825
4. Chemical Feeding Pump	2	1,900.00	3,800	765.00	1,530	5,330
5. Carbon Powder Silo	1	4,500.00	4,500	1,785.00	1,785	6,285
6. Carbon Powder Feeding System	2	21,000.00	42,000	1,275.00	2,550	44,550
7. Portland Cement Silo	1	33,000.00	33,000	51,000.00	51,000	84,000
8. Portland Cement Feeding System	2	17,500.00	35,000	1,275.00	2,550	37,550
9. Fly Ash Silo	1	16,000.00	16,000	25,500.00	25,500	41,500

TABLE B-2 (Continued)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
VIII. CHEMICAL FIXATION SYSTEM (cont'd)						
10. Fly Ash Feeding System	2	15,000.00	30,000	1,275.00	2,550	32,550
11. Sludge Pump	2	8,550.00	17,100	3,250.00	6,500	23,600
12. Process Water Delivery System	1	36,000.00	36,000	27,400.00	27,400	63,400
						382,950
IX. FIXATED SEDIMENT CURING SYSTEM						
1. Curing Basin Dike	600 ft	2.45	1,470	17.85	10,710	12,180
2. Clay Layer	850 cy	20.00	17,000	10.00	8,500	25,500
						37,680
X. OFF-SITE NONHAZARDOUS DISPOSAL*	210,874 ton			100.00	21,087,376	21,087,376
XI. PROCESS PIPING AND I&C	LS		38,000		63,750	101,750
XII. ELECTRICAL	LS		200,000		173,400	373,400
XIII. BUILDINGS, PLATFORMS AND STAIRS	LS		180,000		45,900	225,900
XIV. FOUNDATIONS AND PADS	LS		36,000		142,800	178,800

Total Direct Construction Cost (TDCC)	27,237,097
Contingency @20% of TDCC	5,447,419
Engineering @5% of TDCC	1,361,855
Legal and Administrative @ 2% of TDCC	544,742
Total Construction Cost	34,591,114

* If the fixated sediments must be disposed of as hazardous materials, the unit cost is $230/ton with a disposal cost of $48,501,020 for the 210,874 tons, and a total alternative cost of $105,645,781.

TABLE B-3

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table B-2)						288,592
II. SUPPORT FACILITIES (See Table B-2)						78,000
III. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						2,595,442
IV. CLEAN BACKFILL (See Table B-2)						1,167,347
V. HOLDING TANKS AND MIXERS (See Table B-2)						321,000
VI. SEDIMENT THICKENING SYSTEM (See Table B-2)						120,000
VII. SUPERNATANT TREATMENT SYSTEM (See Table B-2)						278,860
VIII. CHEMICAL FIXATION SYSTEM (See Table B-2)						382,950
IX. FIXATED SEDIMENT CURING SYSTEM (See Table B-2)						37,680
X. ON-SITE NONHAZARDOUS LANDFILL						
1. Liner System						
o Clay Layer (2 ft thick)	26,277 cy	20.00	525,543	10.00	262,772	788,315
o Synthetic Liner	349,546 sf		(Includes Material)	0.90	314,592	314,592

TABLE B-3 (Continued)

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
X. ON-SITE NONHAZARDOUS LANDFILL (cont'd)						
o Geotextile Cloth	328,957 sf	(Includes Material)		0.26	85,529	85,529
o Leachate Collection System						
- PVC Pipe	3,495 ft	0.85	2,971	4.59	16,044	19,015
- RC Sumps	2	600.00	1,200	1,020.00	2,040	3,240
- Pumps	2	5,500.00	11,000	1,530.00	3,060	14,060
o Sand Layer (2 ft thick)	25,128 cy	12.75	320,382	2.30	57,794	378,176
2. Fixated Sediment Hauling, Deposition and Compaction	116,542 cy			8.25	961,475	961,475
3. Capping System						
o Clay Layer (2 ft thick)	25,164 cy	20.00	503,280	10.00	251,640	754,920
o Geotextile Cloth	239,868 sf	(Includes Material)		0.26	62,366	62,366
o Drainage Layer (1 ft thick)	13,147 cy	12.75	167,624	2.30	30,238	197,862
o Topsoil (2 ft thick)	27,356 cy	16.10	440,428	4.54	124,195	564,623
o Vegetation (Grass Seeding)	7.86 acres	1,100.00	8,645	668.00	5,250	13,895
4. Drainage Ditch	3,408 ft			4.59	15,641	15,641
o Clay Layer	9,804 cy	20.00	196,072	22.95	224,992	421,064
o Topsoil	3,266 cy	16.10	52,585	6.63	21,655	74,240
o Vegetation (Grass Seeding)	0.86 acres	1,100.00	941	668.00	572	1,513
						4,670,525
XI. PROCESS PIPING AND I&C (See Table B-2)						101,750
XII. ELECTRICAL (See Table B-2)						373,400

TABLE B-3 (Continued)

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION, $		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
XIII. BUILDINGS, PLATFORMS AND STAIRS (See Table B-2)						225,900
XIV. FOUNDATIONS AND PADS (See Table B-2)						178,800

Total Direct Construction Cost (TDCC)	10,820,246
Contingency @20% of TDCC	2,164,049
Engineering @5% of TDCC	541,012
Legal and Administrative @ 2% of TDCC	216,405
Total Construction Cost	13,741,713

* If the fixated sediments must be disposed of as hazardous materials the cost of the on-site landfill is increased $490,818 for a total on-site landfill cost of $5,161,343 and a total alternative cost of $52,013,040.

TABLE B-4

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table B-2)						288,592
II. SUPPORT FACILITIES (See Table B-2)						78,000
III. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						2,595,442
IV. CLEAN BACKFILL (See Table B-2)						1,167,347
V. SEDIMENT EXTRACTION SYSTEM						
1. Primary Mixing Tanks and Mixer	2	115,000.00	230,000	45,500.00	91,000	321,000
2. Primary Separator	1	63,000.00	63,000	10,000.00	10,000	73,000
3. Primary Slurry Pump	2	17,600.00	35,200	5,900.00	11,800	47,000
4. Water Feeding Pump	2	4,700.00	9,400	1,300.00	2,600	12,000
5. Piping	1,000 lf	20.00	20,000	60.00	60,000	80,000
6. Secondary Mixing Tank	2	70,000.00	140,000	30,000.00	60,000	200,000
7. Separator	1	63,000.00	63,000	10,000.00	10,000	73,000
8. Secondary Slurry Pump	2	17,600.00	35,200	5,900.00	11,800	47,000
9. Process Water Delivery System	1	36,000.00	36,000	27,400.00	27,400	63,400
						916,400
VI. EXTRACTANT TREATMENT SYSTEM						
1. Extractant Oxidation						
o Reactor Tank	2	29,900.00	59,800	38,130.00	76,260	136,060

TABLE B-4 (Continued)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
VI. EXTRACTANT TREATMENT SYSTEM (cont'd)						
o Agitator	2	11,000.00	22,000	1,530.00	3,060	25,060
o Acid Feeder	2	2,500.00	5,000	510.00	1,020	6,020
o Acid Storage Tank	1	6,000.00	6,000	1,530.00	1,530	7,530
o Potassium Permanganate Silo	1	5,000.00	5,000	1,785.00	1,785	6,785
o Potassium Permanganate Feeder	2	30,000.00	60,000	1,275.00	2,550	62,550
2. Extractant Coagulation/Flocculation/ Precipitation						
o Coagulator - Clarifier	2	491,750.00	983,500	179,140	358,280	1,341,780
o Sludge Pump	2	5,500.00	11,000	2,040	4,080	15,080
o Water Pump	4	4,700.00	18,800	1,300	5,200	24,000
o Ferric Chloride Storage Tank	1	9,500.00	9,500	7,650	7,650	17,150
o Ferric Chloride Feeder	2	2,900.00	5,800	510	1,020	6,820
o Polymer Feeder	2	1,200.00	2,400	510	1,020	3,420
o Polymer Day Tank	1	4,400.00	4,400	2,040	2,040	6,440
o Caustic Storage Tank	1	15,000.00	15,000	4,000	4,000	19,000
o Caustic Feeder	2	2,500.00	5,000	510	1,020	6,020
						1,683,715
VII. OFF-SITE NONHAZARDOUS DISPOSAL	105,830 ton			100	10,582,951	10,582,951
VIII. OFF-SITE HAZARDOUS DISPOSAL	8,555 ton			230	1,967,760	1,967,760
IX. PROCESS PIPING AND I&C	LS		60,800		103,000	163,800

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TABLE B-4 (Continued)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
XII. ELECTRICAL	LS		200,000		173,400	373,400
XIII. BUILDINGS, PLATFORMS AND STAIRS	LS		219,000		49,400	268,400
XIV. FOUNDATIONS AND PADS	LS		36,700		145,600	182,300

Total Direct Construction Cost (TDCC)	20,268,107
Contingency @20% of TDCC	4,053,621
Engineering @5% of TDCC	1,013,405
Legal and Administrative @ 2% of TDCC	405,362
Total Construction Cost	25,740,496

* If the extracted sediments must be disposed of as hazardous materials, the unit cost is $230/ton with a disposal cost of $24,340,900 for the 105,830 tons, and a total alternative cost of $46,538,290.

TABLE B-5

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENT TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table B-2)						288,592
II. SUPPORT FACILITIES (See Table B-2)						78,000
III. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						2,595,442
IV. CLEAN BACKFILL (See Table B-2)						1,167,347
V. SEDIMENT EXTRACTION SYSTEM (See Table B-4)						916,400
VI. EXTRACTANT TREATMENT SYSTEM (See Table B-4)						1,683,715
VII. ON-SITE NONHAZARDOUS LANDFILL						
1. Liner System						
o Clay Layer	16,505 cy	20.00	330,107	10.00	165,053	495,160
o Synthetic Liner	219,297 sf		(Includes Material)	0.90	197,367	197,367
o Geotextile Cloth	205,387 sf		(Includes Material)	0.26	53,401	53,401
o Leachate Collection System						
- PVC Pipe	2,193 ft	0.85	1,864	4.59	10,066	11,930
- RC Sumps	2	600.00	1,200	1,020.00	2,040	3,240
- Pumps	2	5,500.00	11,000	1,530.00	3,060	14,060
o Sand Layer	15,727 cy	12.75	200,522	2.30	36,173	236,695
2. Extracted Sediment Hauling, Deposition and Compaction	70,528 cy			8.25	581,859	581,859
3. Capping System						
o Clay Layer	15,589 cy	20.00	311,785	10.00	155,893	467,678

TABLE B-5 (Continued)

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENT TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
VII. ON-SITE NONHAZARDOUS LANDFILL (cont'd)						
o Geotextile Cloth	146,356 sf		(Includes Material)	0.26	38,052	38,052
o Drainage Layer	8,158 cy	12.75	104,014	2.30	18,763	122,778
o Topsoil	16,999 cy	16.10	273,682	4.54	77,175	350,857
o Vegetation (Grass Seeding)	4.84 acres	1,100.00	5,321	668.00	3,231	8,552
4. Drainage Ditch	2,294 ft			4.59	10,531	10,531
o Clay Layer	6,601 cy	20.00	132,016	22.95	151,488	283,504
o Topsoil	2,199 cy	16.10	35,406	6.63	14,580	49,986
o Vegetation (Grass Seeding)	0.58 acres	1,100.00	634	668.00	385	1,019
						2,926,667
VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table B-4)						1,967,760
IX. PROCESS PIPING AND I&C (See Table B-4)						163,800
X. ELECTRICAL (See Table B-4)						373,400
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table B-4)						268,400
XII. FOUNDATIONS AND PADS (See Table B-4)						182,300

Total Direct Construction Cost (TDCC)	12,611,824
Contingency @20% of TDCC	2,522,365
Engineering @5% of TDCC	630,591
Legal and Administrative @ 2% of TDCC	252,236
Total Construction Cost	16,017,016

* If the extracted sediments must be disposed of as hazardous materials the cost of the on-site landfill is increased $357,766 for a total on-site landfill cost of $3,284,433 and a total alternative cost of $20,654,069.

TABLE B-6

ALTERNATIVE 3C - REMOVAL/EXTRACTION/REDEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table B-2)						288,592
II. SUPPORT FACILITIES (See Table B-2)						78,000
III. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						2,595,442
IV. CLEAN BACKFILL	Not required					
V. SEDIMENT EXTRACTION SYSTEM (See Table B-4)						916,400
VI. EXTRACTANT TREATMENT SYSTEM (See Table B-4)						1,683,715
VII. SEDIMENT REDEPOSITION	70,528 cy			5.00	352,642	352,642
VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table B-4)						1,967,760
IX. PROCESS PIPING AND I&C (See Table B-4)						163,800
X. ELECTRICAL (See Table B-4)						373,400
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table B-4)						268,400
XII. FOUNDATIONS AND PADS (See Table B-4)						182,300
Total Direct Construction Cost (TDCC)						8,870,451
Contingency @20% of TDCC						1,774,090
Engineering @5% of TDCC						443,523
Legal and Administrative @ 2% of TDCC						177,409
Total Construction Cost						11,265,473

TABLE B-7

ALTERNATIVE 3D - REMOVAL/EXTRACTION/PLANT SITE DEPOSITION FOR SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table B-2)						288,592
II. SUPPORT FACILITIES (See Table B-2)						78,000
III. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						2,595,442
IV. CLEAN BACKFILL (See Table B-2)						1,167,347
V. SEDIMENT EXTRACTION SYSTEM (See Table B-4)						916,400
VI. EXTRACTANT TREATMENT SYSTEM (See Table B-4)						1,683,715
VII. PLANT SITE DEPOSITION						
1. Hauling/Deposition/Compaction/Grading	70,528 cy			15.00	1,057,925	1,057,925
2. Topsoil (1 ft. thick)	40,333 cy	16.10	649,361	4.54	183,112	832,473
3. Vegetation	20 acres	1,100.00	22,000	668.00	13,360	35,360
						1,925,758
VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table B-4)						1,967,760
IX. PROCESS PIPING AND I&C (See Table B-4)						163,800
X. ELECTRICAL (See Table B-4)						373,400

TABLE B-7 (Continued)

ALTERNATIVE 3D - REMOVAL/EXTRACTION/PLANT SITE DEPOSITION FOR SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	COST	INSTALLATION,$ UNIT PRICE	COST	DIRECT CONSTRUCTION COST, $
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table B-4)						268,400
XII. FOUNDATIONS AND PADS (See Table B-4)						182,300
		Total Direct Construction Cost (TDCC)				11,610,914
		Contingency @20% of TDCC				2,322,183
		Engineering @5% of TDCC				580,546
		Legal and Administrative @ 2% of TDCC				232,218
				Total Construction Cost		14,745,861

TABLE B-8

ALTERNATIVE 5 - IN SITU SAND COVERING

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table B-2)						288,592
II. COARSE SAND COVER INSTALLATION	130,608 cy	12.75	1,665,252	4.00	522,432	2,187,684
			Total Direct Construction Cost (TDCC)			2,476,276
			Contingency @20% of TDCC			495,255
			Engineering @5% of TDCC			123,814
			Legal and Administrative @ 2% of TDCC			49,526
				Total Construction Cost		3,144,870

TABLE B-9

ALTERNATIVE 1 - NO ACTION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection & Report	1 person $60 /hr 40 hrs/yr	$2,400	1-30
b. Ecological Survey & Sampling	6 persons $60 /hr 40 hrs/yr	$14,400	1-30
c. Laboratory Analysis	16 sediment samples $400 /sample	$6,400	1-30
	16 water samples $300 /sample	$4,800	1-30
	40 ecological samples $200 /sample	$8,000	1-30
d. Report	2 persons $60 /hr 40 hrs/yr	$4,800	1-30
	SUBTOTAL	------- $40,800	
2. Public Information Seminar	2 persons $60 /hr 40 hrs/yr	$4,800	1-30
3. Maintenance			
a. Warning Signs	10% of DCC	$1,500	

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4. Contingency	5% of O&M Cost	$2,355	1-30
TOTAL ANNUAL O&M COST		$49,455	1-30

TABLE B-10

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
1. Site Monitoring			
a. Visit Inspection & Report	1 person $60 /hr 40 hrs/yr	$2,400	4-33
b. Laboratory Analysis	16 sediment samples $400 /sample	$6,400	4-33
	4 water samples $300 /sample	$1,200	4-33
c. Report	1 person $60 /hr 40 hrs/yr	$2,400	4-33
2. Monitoring Contingency	5% of O&M Cost	$620	4-33
TOTAL ANNUAL MONITORING O&M COST		$13,020	
Plant Operation			
a. Coagulant Alum	5.92 tons $425 /ton	$2,515	2-3
b. Polymer	0.12 tons $4,000 /ton	$473	2-3
c. Ferric Chloride	5.92 tons $860 /ton	$5,088	2-
d. K-20 LSC	320,831 gal $25 /gal	$8,020,763	2-
e. Activated Carbon	4,278 tons	$6,844,384	2-

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		$1,600 /ton		
f.	Portland Cement	38,500 tons $70 /ton	$2,694,976	2-3
g.	Fly Ash	12,833 tons $50 /ton	$641,661	2-3
		SUBTOTAL	$18,209,860	2-3

TABLE B-10 (Cont'd)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE
NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
2. Manpower			
a. Supervision	1 person $45 /hr 8 hrs/day 365 days/yr	$131,400	2-3
b. Operators	7 person $30 /hr 8 hrs/day 365 days/yr	$613,200	2-3
	SUBTOTAL	$744,600	2-3
3. Power			
a. Operating Equipment	134 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$117,384	2-3
b. Lighting and Trailers	6 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$5,256	2-3
	SUBTOTAL	$122,640	2-3
4. Maintenance	8% of TCC excluding off-site disposal and backfill costs	$506,209	2-3
5. Plant Operation Contingency	5% of O&M Cost	$979,165	2-3
TOTAL ANNUAL PLANT OPERATING COST		$20,562,475	2-3

VIN 002 0516

TABLE B-11

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring and Landfill Maintenance			
1. Landfill Monitoring			
a. Visit Inspection	2 persons $30 /hr 8 hrs/visit 2 visits/yr	$960	4-33
b. Laboratory Analysis	4 leachate samples $1,000 /sample 2 times/yr	$8,000	4-33
c. Report	1 person $60 /hr 8 hrs 2 times/yr	$960	4-33
	SUBTOTAL	$9,920	4-33
2. Landfill Maintenance			
a. Liner System	2% of DCC	$32,059	4-33
b. Cap & Site Repair	2% of DCC	$31,873	4-33
c. Drainage Ditch Repair	2% of DCC	$10,249	4-33
d. Leachate Disposal	1,165 gal $1.00 /gal	$1,165	4-33
	SUBTOTAL	$75,346	4-[illegible]
3. Monitoring and Landfill Maintenance Contingency	5% of O&M Cost	$4,263	4

TOTAL ANNUAL MONITORING O&M COST	$89,530	4-33

Plant Operation

Same as Alt. 2A
See Table B-10

TOTAL ANNUAL PLANT OPERATING COST	$20,562,475	2-3

TABLE B-12

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table B-10		
TOTAL ANNUAL MONITORING O&M COST		$13,020	
Plant Operation			
a. Polymer	0.23 tons $4,000 /ton	$926	2-3
b. Ferric Chloride	83.31 tons $860 /ton	$71,647	2-3
c. Hydrochloric Acid	84.47 tons $320 /ton	$27,030	2-3
d. Potassium Permanganate	13.02 tons $2,800 /ton	$36,455	2-3
e. Sodium Hydroxide	92.06 tons $540 /ton	$49,711	2-3
	SUBTOTAL	$185,768	2-3

TABLE B-12 (Cont'd)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
2. Manpower	Same as Alt. 2A See Table B-10		
	SUBTOTAL	$744,600	2-3
3. Power			
a. Operating Equipment	164 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$143,664	2-3
b. Lighting and Trailers	6 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$5,256	2-3
	SUBTOTAL	$148,920	2-3
4. Maintenance	8% of TCC excluding off-site disposal and backfill costs	$665,485	2-3
5. Plant Operation Contingency	5% of O&M Cost	$87,239	2-3
TOTAL ANNUAL PLANT OPERATING COST		$1,832,012	2-3

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TABLE B-13

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENTS TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring and Landfill Maintenance			
1. Landfill Monitoring	Same as Alt. 2B See Table B-11	$9,920	4-33
2. Landfill Maintenance			
a. Liner System	2% of DCC	$20,237	4-33
b. Cap & Site Repair	2% of DCC	$19,758	4-33
c. Drainage Ditch Repair	2% of DCC	$6,901	4-33
d. Leachate Disposal	705 gal $1.00 /gal	$705	4-33
	SUBTOTAL	$47,601	4-33
3. Monitoring and Landfill Maintenance Contingency	5% of O&M Cost	$2,876	4-33
TOTAL ANNUAL MONITORING O&M COST		$60,398	4-33
Plant Operation			
	Same as Alt. 3A See Table B-12		
TOTAL ANNUAL PLANT OPERATING COST		$1,832,012	2-3

VIN 002 0521

TABLE B-14

ALTERNATIVE 3C - REMOVAL/EXTRACTION/REDEPOSITION OF SEDIMENT/ OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table B-10		
TOTAL ANNUAL MONITORING O&M COST		$13,020	4-33
Plant Operation			
	Same as Alt. 3A See Table B-12		
TOTAL ANNUAL PLANT OPERATING COST		$1,832,012	2-3

VIN 002 0522

TABLE B-15

ALTERNATIVE 3D - REMOVAL/EXTRACTION/PLANT SITE DEPOSITION OF SEDIMENT
OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table B-10		
TOTAL ANNUAL MONITORING O&M COST		$13,020	4-33
Plant Operation			
	Same as Alt. 3A See Table B-12		
TOTAL ANNUAL PLANT OPERATING COST		$1,832,012	2-3

VIN 002 0523

TABLE B-16

ALTERNATIVE 5 - IN SITU SAND COVER

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection & Report	1 person $60 /hr 40 hrs/yr	$2,400	4-33
b. Laboratory Analysis	16 sediment samples $400 /sample	$6,400	4-33
	4 water samples $300 /sample	$1,200	
c. Report	1 person $60 /hr 40 hrs/yr	$2,400	4-33
	SUBTOTAL	$12,400	
2. Contingency	5% of O&M Cost	$620	
TOTAL ANNUAL O&M COST		$13,020	4-33

APPENDIX C

VIN 0020525

TABLE C-1

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION, $		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						
1. Parking Area (included in 2.)						
2. Equipment Parking and Storage Area	1,110 sy	7.50	8,325	6.78	7,526	15,851
3. Security Fence and Gate	1,000 lf	17.60	17,600	33.15	33,150	50,750
4. Access Road	8,333 sy	11.70	97,496	14.94	124,495	221,991
						288,592
II. SUPPORT FACILITIES	5 trailers	15,600.00	78,000			78,000
III. SEDIMENT EXCAVATION	80,285 cy			13.30	1,067,791	1,067,791
IV. CLEAN BACKFILL	80,285 cy	10.00	802,850	4.54	364,494	1,167,344
V. HOLDING TANKS AND MIXERS	2	115,000.00	230,000	45,500.00	91,000	321,000
VI. CHEMICAL FIXATION SYSTEM						
1. Slurry Mixing Tank	2	10,970.00	21,940	4,210.00	8,420	30,360
2. Mixer	2	Included with Slurry Mixing Tank				
3. Chemical Tank (K-20 LSC)	1	10,000.00	10,000	3,825.00	3,825	13,825
4. Chemical Feeding Pump	2	1,900.00	3,800	765.00	1,530	5,330
5. Carbon Powder Silo	1	4,500.00	4,500	1,785.00	1,785	6,285
6. Carbon Powder Feeding System	2	21,000.00	42,000	1,275.00	2,550	44,550
7. Portland Cement Silo	1	33,000.00	33,000	51,000.00	51,000	84,000

TABLE C-1 (Continued)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
VI. CHEMICAL FIXATION SYSTEM (cont'd)						
8. Portland Cement Feeding System	2	17,500.00	35,000	1,275.00	2,550	37,550
9. Fly Ash Silo	1	16,000.00	16,000	25,500.00	25,500	41,500
10. Fly Ash Feeding System	2	15,000.00	30,000	1,275.00	2,550	32,550
11. Sludge Pump	2	8,550.00	17,100	3,250.00	6,500	23,600
12. Process Water Delivery System	1	36,000.00	36,000	27,400.00	27,400	63,400
13. Sediment Belt Conveyor and Hopper	3	34,550.00	103,650	10,660.00	31,980	135,630
						518,580
VII. FIXATED SEDIMENT CURING SYSTEM						
1. Curing Basin Dike	600 ft	2.45	1,470	17.85	10,710	12,180
2. Clay Layer	850 cy	20.00	17,000	10.00	8,500	25,500
						37,680
VIII. OFF-SITE NONHAZARDOUS DISPOSAL*	210,873 ton			100.00	21,087,323	21,087,323
IX. PROCESS PIPING AND I&C	LS		38,000		63,750	101,750
X. ELECTRICAL	LS		200,000		173,400	373,400
XI. BUILDINGS, PLATFORMS AND STAIRS	LS		180,000		45,900	225,900
XII. FOUNDATIONS AND PADS	LS		36,000		142,800	178,800

Total Direct Construction Cost (TDCC)	25,446,160
Contingency @20% of TDCC	5,089,232
Engineering @5% of TDCC	1,272,308
Legal and Administrative @ 2% of TDCC	508,923
Total Construction Cost	32,316,623

* If the fixated sediments must be disposed of as hazardous materials, the unit cost is $230/ton with a disposal cost of $48,500,790 for the 210,873 tons, and a total alternative cost of $103,238,918.

TABLE C-2

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table C-1)						288,592
II. SUPPORT FACILITIES (See Table C-1)						78,000
III. SEDIMENT EXCAVATION (See Table C-1)						1,067,791
IV. CLEAN BACKFILL (See Table C-1)						1,167,344
V. HOLDING TANKS AND MIXERS (See Table C-1)						321,000
VI. CHEMICAL FIXATION SYSTEM (See Table C-1)						518,580
VII. FIXATED SEDIMENT CURING SYSTEM (See Table C-1)						37,680
VIII. ON-SITE NONHAZARDOUS LANDFILL						
1. Liner System						
o Clay Layer (2 ft thick)	26,277 cy	20.00	525,542	10.00	262,771	788,313
o Synthetic Liner	349,545 sf		(Includes Material)	0.90	314,591	314,591
o Geotextile Cloth	328,956 sf		(Includes Material)	0.26	85,529	85,529
o Leachate Collection System						
- PVC Pipe	3,495 ft	0.85	2,971	4.59	16,044	19,015
- RC Sumps	2	600.00	1,200	1,020.00	2,040	3,240
- Pumps	2	5,500.00	11,000	1,530.00	3,060	14,060
o Sand Layer (2 ft thick)	25,128 cy	12.75	320,381	2.30	57,794	378,175
2. Fixated Sediment Hauling, Deposition and Compaction	116,542 cy			8.25	961,473	961,473

VIN 002 0528

TABLE C-2 (Continued)

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
VIII. ON-SITE NONHAZARDOUS LANDFILL (cont'd)						
3. Capping System						
o Clay Layer (2 ft thick)	25,164 cy	20.00	503,279	10.00	251,639	754,918
o Geotextile Cloth	239,868 sf		(Includes Material)	0.26	62,366	62,366
o Drainage Layer (1 ft thick)	13,147 cy	12.75	167,624	2.30	30,238	197,862
o Topsoil (2 ft thick)	27,356 cy	16.10	440,427	4.54	124,195	564,622
o Vegetation (Grass Seeding)	7.86 acres	1,100.00	8,645	668.00	5,250	13,895
4. Drainage Ditch	3,408 ft			4.59	15,641	15,641
o Clay Layer	9,804 cy	20.00	196,071	22.95	224,992	421,063
o Topsoil	3,266 cy	16.10	52,585	6.63	21,655	74,240
o Vegetation (Grass Seeding)	0.86 acres	1,100.00	941	668.00	572	1,513
						4,670,514
IX. PROCESS PIPING AND I&C (See Table C-1)						101,750
X. ELECTRICAL (See Table C-1)						373,400

TABLE C-2 (Continued)

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table C-1)						225,900
XII. FOUNDATIONS AND PADS (See Table C-1)						178,800

* If the fixated sediments must be disposed of as hazardous materials the cost of the on-site landfill is increased $511,018 for a total on-site landfill cost of $5,181,532 and a total alternative cost of $49,381,892.

Total Direct Construction Cost (TDCC)	9,029,350
Contingency @20% of TDCC	1,805,870
Engineering @5% of TDCC	451,468
Legal and Administrative @ 2% of TDCC	180,587
Total Construction Cost	11,467,275

TABLE C-3

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table C-1)						288,592
II. SUPPORT FACILITIES (See Table C-1)						78,000
III. SEDIMENT EXCAVATION (See Table C-1)						1,067,791
IV. CLEAN BACKFILL (See Table C-1)						1,167,344
V. SEDIMENT EXTRACTION SYSTEM						
1. Primary Mixing Tanks and Mixer	2	115,000.00	230,000	45,500.00	91,000	321,000
2. Primary Separator	1	63,000.00	63,000	10,000.00	10,000	73,000
3. Primary Slurry Pump	2	17,600.00	35,200	5,900.00	11,800	47,000
4. Water Feeding Pump	2	4,700.00	9,400	1,300.00	2,600	12,000
5. Piping	1,000 lf	20.00	20,000	60.00	60,000	80,000
6. Secondary Mixing Tank	2	70,000.00	140,000	30,000.00	60,000	200,000
7. Separator	1	63,000.00	63,000	10,000.00	10,000	73,000
8. Secondary Slurry Pump	2	17,600.00	35,200	5,900.00	11,800	47,000
9. Process Water Delivery System	1	36,000.00	36,000	27,400.00	27,400	63,400
10. Sediment Belt Conveyor and Hopper	3	34,550.00	103,650	10,660.00	31,980	135,630
						1,052,030
VI. EXTRACTANT TREATMENT SYSTEM						
1. Extractant Oxidation						
o Reactor Tank	2	29,900.00	59,800	38,130.00	76,260	136,060

TABLE C-3 (Continued)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION, $ UNIT PRICE	INSTALLATION, $ COST	DIRECT CONSTRUCTION COST, $
VI. EXTRACTANT TREATMENT SYSTEM (cont'd)						
o Agitator	2	11,000.00	22,000	1,530.00	3,060	25,060
o Acid Feeder	2	2,500.00	5,000	510.00	1,020	6,020
o Acid Storage Tank	1	6,000.00	6,000	1,530.00	1,530	7,530
o Potassium Permanganate Silo	1	5,000.00	5,000	1,785.00	1,785	6,785
o Potassium Permanganate Feeder	2	30,000.00	60,000	1,275.00	2,550	62,550
2. Extractant Coagulation/Flocculation/ Precipitation						
o Coagulator - Clarifier	2	491,750.00	983,500	179,140	358,280	1,341,780
o Sludge Pump	2	5,500.00	11,000	2,040	4,080	15,080
o Water Pump	4	4,700.00	18,800	1,300	5,200	24,000
o Ferric Chloride Storage Tank	1	9,500.00	9,500	7,650	7,650	17,150
o Ferric Chloride Feeder	2	2,900.00	5,800	510	1,020	6,820
o Polymer Feeder	2	1,200.00	2,400	510	1,020	3,420
o Polymer Day Tank	1	4,400.00	4,400	2,040	2,040	6,440
o Caustic Storage Tank	1	15,000.00	15,000	4,000	4,000	19,000
o Caustic Feeder	2	2,500.00	5,000	510	1,020	6,020
						1,683,715
VII. OFF-SITE NONHAZARDOUS DISPOSAL	105,829 ton			100	10,582,924	10,582,924
VIII. OFF-SITE HAZARDOUS DISPOSAL	8,555 ton			230	1,967,755	1,967,755
XI. PROCESS PIPING AND I&C	LS		60,800		103,000	163,800

TABLE C-3 (Continued)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
X. ELECTRICAL	LS		200,000		173,400	373,400
XI. BUILDINGS, PLATFORMS AND STAIRS	LS		219,000		49,400	268,400
XII. FOUNDATIONS AND PADS	LS		36,700		145,600	182,300

Total Direct Construction Cost (TDCC)	18,876,051
Contingency @20% of TDCC	3,775,210
Engineering @5% of TDCC	943,803
Legal and Administrative @ 2% of TDCC	377,521
Total Construction Cost	23,972,585

* If the extracted sediments must be disposed of as hazardous materials, the unit cost is $230/ton with a disposal cost of $24,340,670 for the 105,829 tons, and a total alternative cost of $44,269,107.

TABLE C-4

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENT TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table C-1)						288,592
II. SUPPORT FACILITIES (See Table C-1)						78,000
III. SEDIMENT EXCAVATION (See Table C-1)						1,067,791
IV. CLEAN BACKFILL (See Table C-1)						1,167,344
V. SEDIMENT EXTRACTION SYSTEM (See Table C-3)						1,052,030
VI. EXTRACTANT TREATMENT SYSTEM (See Table C-3)						1,683,715
VII. ON-SITE NONHAZARDOUS LANDFILL						
1. Liner System						
o Clay Layer	16,505 cy	20.00	330,106	10.00	165,053	495,159
o Synthetic Liner	219,296 sf		(Includes Material)	0.90	197,367	197,367
o Geotextile Cloth	205,386 sf		(Includes Material)	0.26	53,400	53,400
o Leachate Collection System						
- PVC Pipe	2,193 ft	0.85	1,864	4.59	10,066	11,930
- RC Sumps	2	600.00	1,200	1,020.00	2,040	3,240
- Pumps	2	5,500.00	11,000	1,530.00	3,060	14,060
o Sand Layer	15,727 cy	12.75	200,522	2.30	36,173	236,694
2. Extracted Sediment Hauling, Deposition and Compaction	70,528 cy			8.25	581,857	581,857
3. Capping System						
o Clay Layer	15,589 cy	20.00	311,784	10.00	155,892	467,677

TABLE C-4 (Continued)

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENT TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
VII. ON-SITE NONHAZARDOUS LANDFILL (cont'd)						
o Geotextile Cloth	146,355 sf		(Includes Material)	0.26	38,052	38,052
o Drainage Layer	8,158 cy	12.75	104,014	2.30	18,763	122,778
o Topsoil	16,999 cy	16.10	273,682	4.54	77,175	350,856
o Vegetation (Grass Seeding)	4.84 acres	1,100.00	5,321	668.00	3,231	8,552
4. Drainage Ditch	2,294 ft			4.59	10,531	10,531
o Clay Layer	6,601 cy	20.00	132,016	22.95	151,488	283,503
o Topsoil	2,199 cy	16.10	35,406	6.63	14,580	49,986
o Vegetation (Grass Seeding)	0.58 acres	1,100.00	634	668.00	385	1,019
						2,926,661
VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table C-3)						1,967,755
IX. PROCESS PIPING AND I&C (See Table C-3)						163,800
X. ELECTRICAL (See Table C-3)						373,400
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table C-3)						268,400
XII. FOUNDATIONS AND PADS (See Table C-3)						182,300

Total Direct Construction Cost (TDCC)	11,219,788
Contingency @20% of TDCC	2,243,958
Engineering @5% of TDCC	560,989
Legal and Administrative @ 2% of TDCC	224,396
Total Construction Cost	14,249,130

* If the extracted sediments must be disposed of as hazardous materials the cost of the on-site landfill is increased $370,136 for a total on-site landfill cost of $3,296,797 and a total alternative cost of $18,275,675.

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TABLE C-5

ALTERNATIVE 3C - REMOVAL/EXTRACTION/REDEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $ UNIT PRICE	MATERIAL, $ COST	INSTALLATION,$ UNIT PRICE	INSTALLATION,$ COST	DIRECT CONSTRUCTION COST, $
I. SITE PREPARATION (See Table C-1)						288,592
II. SUPPORT FACILITIES (See Table C-1)						78,000
III. SEDIMENT EXCAVATION (See Table C-1)						1,067,791
IV. CLEAN BACKFILL	Not required					
V. SEDIMENT EXTRACTION SYSTEM (See Table C-3)						1,052,030
VI. EXTRACTANT TREATMENT SYSTEM (See Table C-3)						1,683,715
VII. SEDIMENT REDEPOSITION	70,528 cy			5.00	352,641	352,641
VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table C-3)						1,967,755
IX. PROCESS PIPING AND I&C (See Table C-3)						163,800
X. ELECTRICAL (See Table C-3)						373,400
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table C-3)						268,400
XII. FOUNDATIONS AND PADS (See Table C-3)						182,300

Total Direct Construction Cost (TDCC)	7,478,424
Contingency @20% of TDCC	1,495,685
Engineering @5% of TDCC	373,921
Legal and Administrative @ 2% of TDCC	149,568
Total Construction Cost	9,497,598

TABLE C-6

ALTERNATIVE 3D - REMOVAL/EXTRACTION/PLANT SITE DEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table C-1)						288,592
II. SUPPORT FACILITIES (See Table C-1)						78,000
III. SEDIMENT EXCAVATION (See Table C-1)						1,067,791
IV. CLEAN BACKFILL (See Table C-1)						1,167,344
V. SEDIMENT EXTRACTION SYSTEM (See Table C-3)						1,052,030
VI. EXTRACTANT TREATMENT SYSTEM (See Table C-3)						1,683,715
VII. PLANT SITE DEPOSITION						
1. Hauling/Deposition/Compaction/Grading	70,528 cy			15.00	1,057,922	1,057,922
2. Topsoil (1 ft thick)	40,333 acres	16.10	649,361	4.54	183,112	832,473
3. Vegetation	20 cy	1,100.00	22,000	668.00	13,360	35,360

						1,925,755
VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table C-3)						1,967,755
IX. PROCESS PIPING AND I&C (See Table C-3)						163,800
X. ELECTRICAL (See Table C-3)						373,400

TABLE C-6 (Continued)

ALTERNATIVE 3D - REMOVAL/EXTRACTION/PLANT SITE DEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION,$		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
XI. BUILDINGS, PLATFORMS AND STAIRS (See Table C-3)						268,400
XII. FOUNDATIONS AND PADS (See Table C-3)						182,300
			Total Direct Construction Cost (TDCC)			10,218,882
			Contingency @20% of TDCC			2,043,776
			Engineering @5% of TDCC			510,944
			Legal and Administrative @ 2% of TDCC			204,378
					Total Construction Cost	12,977,980

TABLE C-7

ALTERNATIVE 5 - IN SITU SAND COVER

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL, $		INSTALLATION, $		DIRECT CONSTRUCTION COST, $
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table C-1)						288,592
II. COARSE SAND COVER INSTALLATION	80,285 cy	12.75	1,023,634	5.00	401,425	1,425,059
		Total Direct Construction Cost (TDCC)				1,713,651
		Contingency @20% of TDCC				342,730
		Engineering @5% of TDCC				85,683
		Legal and Administrative @ 2% of TDCC				34,273
				Total Construction Cost		2,176,336

TABLE C-8

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
1. Site Monitoring			
a. Visit Inspection & Report	1 person $60 /hr 40 hrs/yr	$2,400	4-33
b. Laboratory Analysis	16 sediment samples $400 /sample	$6,400	4-33
	4 water samples $300 /sample	$1,200	4-33
c. Report	1 person $60 /hr 40 hrs/yr	$2,400	4-33
2. Monitoring Contingency	5% of O&M Cost	$620	4-33
TOTAL ANNUAL MONITORING O&M COST		$13,020	
Plant Operation			
a. K-20 LSC	320,830 gal $25 /gal	$8,020,742	2-3
b. Activated Carbon	4,278 tons $1,600 /ton	$6,844,367	2-3
c. Portland Cement	38,500 tons $70 /ton	$2,694,969	2-3
d. Fly Ash	12,833 tons $50 /ton	$641,659	2-3
	SUBTOTAL	$18,201,738	2-3

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TABLE C-8 (Cont'd)

ALTERNATIVE 2A - REMOVAL/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
2. Manpower			
a. Supervision	1 person $45 /hr 8 hrs/day 365 days/yr	$131,400	2-3
b. Operators	7 person $30 /hr 8 hrs/day 365 days/yr	$613,200	2-3
	SUBTOTAL	$744,600	2-3
3. Power			
a. Operating Equipment	134 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$117,384	2-3
b. Lighting and Trailers	6 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$5,256	2-3
	SUBTOTAL	$122,640	2-3
4. Maintenance	8% of TCC excluding off-site disposal costs	$442,858	2-3
5. Plant Operation Contingency	5% of O&M Cost	$975,592	2-3
TOTAL ANNUAL PLANT OPERATING COST		$20,487,428	2-3

TABLE C-9

ALTERNATIVE 2B - REMOVAL/FIXATION/ON-SITE
NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring and Landfill Maintenance			
1. Landfill Monitoring			
a. Visit Inspection	2 persons $30 /hr 8 hrs/visit 2 visits/yr	$960	4-33
b. Laboratory Analysis	4 leachate samples $1,000 /sample 2 times/yr	$8,000	4-33
c. Report	1 person $60 /hr 8 hrs 2 times/yr	$960	4-33
	SUBTOTAL	$9,920	4-33
2. Landfill Maintenance			
a. Liner System	2% of DCC	$32,058	4-33
b. Cap & Site Repair	2% of DCC	$31,873	4-33
c. Drainage Ditch Repair	2% of DCC	$10,249	4-33
d. Leachate Disposal	1,165 gal $1.00 /gal	$1,165	4-33
	SUBTOTAL	$75,346	4-3
3. Monitoring and Landfill Maintenance Contingency	5% of O&M Cost	$4,263	4-3

TOTAL ANNUAL MONITORING O&M COST	$89,530	4-33

Plant Operation

Same as Alt. 2A
See Table C-8

TOTAL ANNUAL PLANT OPERATING COST	$20,487,428	2-3

TABLE C-10

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table C-8		
TOTAL ANNUAL MONITORING O&M COST		$13,020	
Plant Operation			
a. Polymer	0.23 tons $4,000 /ton	$926	2-3
b. Ferric Chloride	83.31 tons $860 /ton	$71,647	2-3
c. Hydrochloric Acid	84.47 tons $320 /ton	$27,030	2-3
d. Potassium Permanganate	13.02 tons $2,800 /ton	$36,454	2-3
e. Sodium Hydroxide	92.06 tons $540 /ton	$49,711	2-3
	SUBTOTAL	$185,768	2-3

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TABLE C-10 (Cont'd)

ALTERNATIVE 3A - REMOVAL/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
2. Manpower	Same as Alt. 2A See Table C-8		
	SUBTOTAL	$744,600	2-3
3. Power			
a. Operating Equipment	164 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$143,664	2-3
b. Lighting and Trailers	6 kw 24 hrs/day 365 days/yr $0.10 /kwhr	$5,256	2-3

	SUBTOTAL	$148,920	2-3
4. Maintenance	5% of TCC excluding off-site disposal costs	$642,658	2-3
5. Plant Operation Contingency	5% of O&M Cost	$86,097	2

TOTAL ANNUAL PLANT OPERATING COST		$1,808,043	2

TABLE C-11

ALTERNATIVE 3B - REMOVAL/EXTRACTION/SEDIMENTS TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring and Landfill Maintenance			
1. Landfill Monitoring	Same as Alt. 2B See Table C-9	$9,920	4-33
2. Landfill Maintenance			
a. Liner System	2% of DCC	$20,237	4-33
b. Cap & Site Repair	2% of DCC	$19,758	4-33
c. Drainage Ditch Repair	2% of DCC	$6,901	4-33
d. Leachate Disposal	705 gal $1.00 /gal	$705	4-33
	SUBTOTAL	$47,601	4-33
3. Monitoring and Landfill Maintenance Contingency	5% of O&M Cost	$2,876	4-33
TOTAL ANNUAL MONITORING O&M COST		$60,397	4-33
Plant Operation			
	Same as Alt. 3A See Table C-10		
TOTAL ANNUAL PLANT OPERATING COST		$1,808,043	2-3

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TABLE C-12

ALTERNATIVE 3C - REMOVAL/EXTRACTION/
REDEPOSITION OF SEDIMENTS/OFF-SITE
HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table C-8		
TOTAL ANNUAL MONITORING O&M COST		$13,020	4-33
Plant Operation			
	Same as Alt. 3A See Table C-10		
TOTAL ANNUAL PLANT OPERATING COST		$1,808,043	2-3

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TABLE C-13

ALTERNATIVE 3D - REMOVAL/EXTRACTION/
PLANT SITE DEPOSITION OF SEDIMENTS/
OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table C-8		
TOTAL ANNUAL MONITORING O&M COST		$13,020	4-33
Plant Operation			
	Same as Alt. 3A See Table C-10		
TOTAL ANNUAL PLANT OPERATING COST		$1,808,043	2-3

TABLE C-14

ALTERNATIVE 5 - IN SITU SAND COVER

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O&M COST ESTIMATE	YEAR
Monitoring			
	Same as Alt. 2A See Table C-8		
TOTAL ANNUAL MONITORING O&M COST		$13,020	4-33
TOTAL ANNUAL PLANT OPERATING COST		$13,020	4-33

APPENDIX D

VIN 002 0550

APPENDIX D

STATISTICAL ANALYSES
OF SEDIMENT ARSENIC DATA

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STATISTICAL ANALYSES OF ARSENIC DATA

PURPOSE

Statistical analyses were performed on the soil arsenic data from the Union Lake site. The purpose of the analysis was to prepare an unbiased estimate of the quantity of sediment which contained an arsenic concentration above the original action level of 32.5 mg/kg. This unbiased estimate could then be used as the basis for determining areas and depths of contamination correlating with the remediation criteria. As discussed in Section 2. The remediation criteria is as follows:

- In the most accessible areas of the lake (the public beach and the tennis and sailing club) all sediments underlying a water depth of less than five feet with an arsenic concentration of 20 mg/kg or greater would be remediated.

- In the residential areas of the lake along the eastern shoreline, all sediments underlying a water depth of less than two and one-half feet with an arsenic concentration of 20 mg/kg or greater would be remediated. Thereafter, the remediation would be extended to remove sediments with an arsenic concentration above 20 mg/kg within 150 feet of the shoreline, up to a five foot water depth.

- For the remaining areas of the lake, where activities that promote sediment ingestion are less likely to be engaged in, the action level would be 120 mg/kg. Remediation would be conducted to a two and one-half foot water depth at a minimum. Thereafter, the remediation would be extended to remove sediments with an arsenic concentration above 120 mg/kg within 150 feet of the shoreline, up to a five foot water depth.

METHODOLOGY

As discussed in the Draft Union Lake RI report (Ebasco, 1988e), sediment sampling was performed during the investigation. Surface sediment samples and samples from 0-1 feet were taken at 62 locations.

All of the above samples were analyzed for total arsenic. The arsenic results are presented in Section 1 of this FS Report, and are discussed in detail in the Union Lake Site RI. These samples provided the data base used to estimate the contaminated sediment volumes.

The first step in the process was to determine the horizontal coordinates of each sediment sampling point. This was done for all surface samples and samples in the range of 0-1 ft. All the sample points were considered as being surface samples (i.e., depth not considered) and analyzed by the methods outlined in the Statistical Analyses section below to contour the arsenic data. Those areas within each depth range that displayed arsenic concentrations greater than 32.5 mg/kg were determined from the contours. The contours were compared with a map showing all of the sediment arsenic concentrations to characterize areas having sediment arsenic concentrations above the action level of 20 mg/kg in the more accessible areas and 120 mg/kg in the less accessible areas. These modified areas were overlaid on a map of the lake showing the depth of water. This permitted determination of the areas that met the remediation criteria. Planimetry was then employed to estimate the area of contamination. The volume of contaminated sediment was obtained using an assumed depth of contamination of one foot.

STATISTICAL ANALYSES

Although the algorithm used for the statistical analysis was unbiased, the algorithm did contain numerous parameters. Therefore the first step in data reduction was to perform a detailed sensitivity analysis to determine the parameters that had a significant affect on the contour maps generated. The magnitude of each effect was also determined. This data was then used to guide the second stage of data reduction and interpretation.

Results of the sensitivity analysis indicated that the contour maps produced were not significantly affected by variations of the contouring algorithm utilized. Minor differences in specific contours were observed, however, when calculations were made to estimate quantities of contaminated material. These differences were found to be insignificant when compared to the total quantity of material to be removed.

Although variations in contouring algorithms were not identified as potential sources of error, a secondary problem associated with any mathematical model needed to be considered. This problem, inherent in all mathematical interpolation algorithms, is known as the boundary affect. Empirically, for the Union Lake sediments, this resulted in contours within approximately 50-100 ft of a boundary being suspect. These contours needed to be evaluated by hand, based on professional judgement. This interpretation was performed in the second stage of data reduction.

Although the computer algorithm proved to be relatively insensitive to variations in input parameters, a discussion of the various parameters evaluated is warranted. Input parameters, for this discussion, can be grouped into two categories:

1. Parameters affecting data point selection; and
2. Parameters affecting interpolation technique.

Parameters in the first category include the method of selecting data points for interpolation, the maximum distance between points to be evaluated, and the handling of duplicate data points. Parameters in the second category include the mathematical algorithm used, distance weighing factors, and grid node spacing (roughly correlates to "how creative" one desires the computer to be).

Several factors had to be taken into account when defining a search methodology. Of primary concern was the spatial distribution of the data. Two different methods were applied in searching for data points to be evaluated in determining the value to be assigned to a grid location. The standard (NORMAL) method designed for randomly distributed data simply selects the (n) closest points. Values of (n) ranging from 3 to 10 were investigated.

The search radius is defined as the maximum distance at which a data point will be considered by the algorithm. In general the larger the search radius the smoother the resulting map. However, when there is a great amount of evenly distributed data the number of data points considered (n) is usually reached prior to the maximum search radius. A conservative search radius of 1000 ft was used because a geochemical influence at a node by a data point over 1000 ft away is technically unlikely.

The type of interpolation algorithm to be used for reducing the data depended on several factors, including data density and the physical process that was being investigated. A KRIGING algorithm was chosen as the method used to determine the weighted average of a data point when computing the value at a grid node. The KRIGING method was chosen instead of an INVERSE DISTANCE SQUARED (IDS) method. Although the data was fairly well distributed over the site, this distribution was not totally uniform. If an IDS method of weighing had been used, less realistic values would have been calculated for grid nodes located in areas with low data density. In addition, the assumption that arsenic concentration could be considered to vary over the lake in a continuous (although complex) manner was technically reasonable. This was one of the major assumptions that had to be met in order for the KRIGING algorithm to be validly applied.

The weighted average, utilizing the KRIGING method, was related to the cube root of the distance between the data point and the grid node. Tests were conducted using this algorithm based on a square root and a fifth root distance weighing scheme, but because the data was distributed in a fairly uniform manner, the weighing scheme was not as sensitive to variation as one might expect. Therefore a KRIGING algorithm based on the square root of the distance between points was used.

A grid size of 50 was chosen for the X axis which roughly corresponded to a grid line on each data point and one grid line interpolated between each data point. A higher density grid would have provided more detailed contours, but they would have been based on computer interpolation of data to a much greater extent. In addition, the increase in computer memory and processing time requirements is not a linear function, therefore, the resulting aesthetic improvement would not have been justified.

In addition, evaluating the above parameters, individual contour lines were smoothed between grid nodes by a cubic spline method. This did not affect the values determined at each grid node (see discussion of KRIGING above). Therefore this smoothing did not override the KRIGING performed on the raw data.

ADJUSTMENT OF COMPUTER DATA

By applying the above contouring techniques on the sediment arsenic data, maps were generated which showed contoured arsenic concentrations within each data set: surface and 0-1 foot depth. These maps were compared and overlaid to determine the unbiased estimate of the area and depth of soil containing an arsenic concentration above 32.5 mg/kg. By hand adjusting these contour lines around locations which met the remediation criteria, the areas of contamination were determined.

This process resulted in producing the sediment areas for remediation shown in Figure 3-2.


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